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"Elucidating the Synergy Between Green Human Resource Management and the Triple Bottom Line Perspective of Sustainable Development: An Examination of the Mediating Role of Industry 4.0 Technological Advancements"

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Abstract

The rising concern of stakeholders for sustainable development has caused managers to adopt policies that ensure it. One such way is to incorporate Green policies in human resource management practices. However, one major factor in this relationship is new advancements in Industry 4.0 technologies, which have both positive and negative impacts. Therefore this study aims to examine the relation of GHRM with sustainable development and its triple bottom line perspective along with the mediating role of Industry 4.0 in this relationship. The study was conducted in the aviation field and data was collected from 16 airlines in the Middle East and Pakistan, utilizing the PLS-SEM method. The findings have revealed that there is a significant and positive relationship between GHRM with sustainable development and its triple bottom line perspective and Industry 4.0 acts as a suppressor in the mediating role of this relation. Further, the theoretical and practical implications of this study are discussed.

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Keywords: Green Human Resource Management, Aviation Industry, Industry 4.0, Sustainable development

Introduction

A high-performing firm may pursue sustainable development, which is becoming more and more important for all organizations. There are many concepts and applications linked to sustainable development. Furthermore, companies who wish to be environmentally responsible are finding that it is becoming increasingly important to make contributions that go above and beyond the economic benefits. Because of this, organizational focus has become more crucial to sustainable growth in recent years (Rafiq et al., 2020). To achieve this sustainable development organizations are incorporating Green practices in their human resource policies, known as Green Human resources management GHRM. Employing Green HRM, or environmentally friendly HRM techniques, is one way that many businesses have responded to the environmental problems that society faces. As public awareness of the environmental implications of corporate activities, such as increased pollution and climate change, and their effects on society grow, businesses and governments are responding to the growing environmental concerns (Tanova & Bayighomog, 2022).

Governments and corporations are under pressure from many sectors to act more decisively and put in place more efficient policies. The stakeholders not only need to stop further harm from happening, but also find out how to repair any previously done harm. By using their purchasing power and making sure that they, as individuals, avoid purchasing products or services produced by companies that are not perceived as acting in an environmentally sustainable manner, customers are influencing government policies to bind the policies and business activities that may harm the environment. An increasing number of top-level managers have committed to keeping sustainability at the top of their agendas (Paulet et al., 2021).

Furthermore, researchers and management have focused more on how companies are developing and executing plans to be more environmentally sensitive (Tanova & Bayighomog, 2022). The paradigm change from human resource management to green human resource management has opened up new possibilities, and its effects on sustainable development from the

triple bottom line perspective are currently being studied. Moreover, scholars and institutions find the connection between GHRM and SD in the context of Industry 4.0 to be significant. There are now more opportunities for scholars to find these viewpoints because of this unexplored but inevitable future.

Therefore, this study aims to bridge the gap in existing knowledge by exploring the relationship between GHRM and the TBL perspective of sustainable development, as well as the mediating role of Industry 4.0. The research objectives and hypotheses are designed to provide empirical insights into this unexplored yet crucial area of study

The study aims to bridge the gap in existing knowledge by describing the concepts of GHRM, the TBL perspective of sustainable development, and Industry 4.0 by examining the relationship between GHRM and the triple bottom line (TBL) perspective of SD, with the mediating impact of Industry 4.0. GHRM represents the integration of environmental sustainability principles into human resource management practices, aiming to foster a culture of environmental responsibility among employees. The advent of Industry 4.0, characterized by the integration of advanced digital technologies, is transforming organizational operations and potentially influencing the GHRM-sustainable development relationship. The GHRM paradigm's research focuses mostly on human and leadership components, with an appropriate amount of technology research absent. As a result, our work will not just bridge the information gap but also provide future scholars with fresh avenues for investigation.

Literature Review

In recent years, there has been an increasing desire from academic researchers and industry personnel to create ecologically friendly workplaces. This heightened emphasis has given rise to several study fields focused on environmental sustainability, one of which stands out in particular: GHRM. The concept of the "green workplace" entails incorporating environmental sustainability ideas into conventional corporate operations, which include crucial domains like marketing, supply chain management, operations, and human resource management. The study of how environmental sustainability and human resource practices interact inside enterprises has given rise to a new area of GHRM. It is an example of a strategic approach that combines green concepts with human

resource management, which is essential for assisting firms in creating and implementing sustainable initiatives. GHRM is more than just a theoretical idea; it is a useful framework that helps businesses accomplish their objectives concerning corporate sustainability (Bahuguna et al., 2023).

As per Singh et al. (2021), senior management's perspective of human resources as a strategic asset for business progress is shown by the significance of GHRM practices in improving organizational performance. Companies may cultivate an atmosphere that encourages innovation and guarantees that long-term performance objectives are in line with the efficient use of internal resources to tackle risks and problems by carefully placing human resources inside the organizational structure. With this strategic strategy, the firm is positioned for long-term success in its sector. Finding a balance between resource consumption and economic growth is necessary for organizations to enhance sustainable performance, which is why it is becoming more and more important for them to include environmentally friendly business practices in their operations. (Mousa & Othman, 2020). Adopting green policies on a larger scale is supported by governments, public organizations, environmental groups, partners, stakeholders, consumers, and society at large. Beyond organizational expansion and economic development, more subtle integration with social improvement is one of the expected results. (El-Kassar et al., 2019).

The global industries are rapidly being overtaken by a new revolution called Industry 4.0. A novel development in automation and data sharing called Industry 4.0 is being adopted by a large number of companies globally. This revolution entails combining informatics and modern manufacturing methods to create intelligent systems (Caiado et al., 2021). The term "Industry 4.0" initially appeared in 2011 at the Hannover Fair in Germany, while a team of researchers headed by the Research Union Economy-Science of the German Ministry of Education and Research first presented the concept (Culot et al., 2020). A new outlook on company performance and future technology growth is evident in the adoption of Industry 4.0 technologies (Javaid et al., 2022). Their implementation of organizational strategies for Industry 4.0 improvements has given them a competitive advantage over rivals. They may bring in a new age of production and delivery by providing total control over material flow and supply by combining data-driven input with flexible and effective automation. Industry 4.0 offers several advantages, such as improved performance

and competitiveness, higher profitability, and more adaptability and resilience. At the same time there are negative impacts of the technologies and have an adverse effect on the sustainability of the environment due to air pollution, inadequate waste disposal, and excessive consumption of energy, information, and raw materials (Oláh et al., 2020).

The relation of GHRM with SD is crucial to acknowledge the correct direction of HR policy efforts to achieve environmentally friendly outcomes. The positive or negative role of technologies of Industry 4.0 as the mediator in the relation of GHRM and SD is yet another new dimension that is required to be examined. Therefore, given above mentioned literature, we have established the following hypotheses to be confirmed in this study

H1: GHRM has a positive impact on sustainable development

H2: GHRM has a positive effect on the Economic perspective of sustainable development

H3: GHRM has a positive impact on the Environmental perspective of sustainable development

H4: GHRM has a positive impact on the Social perspective of sustainable development

H5: Industry 4.0 mediated the relationship between GHRM and the sustainable development

H6: Industry 4.0 mediates the relationship between GHRM and the Economic perspective of sustainable development

H7: Industry 4.0 mediates the relationship between GHRM and the Environmental perspective of sustainable development

H8: Industry 4.0 mediates the relation between GHRM and the Social perspective of sustainable development.

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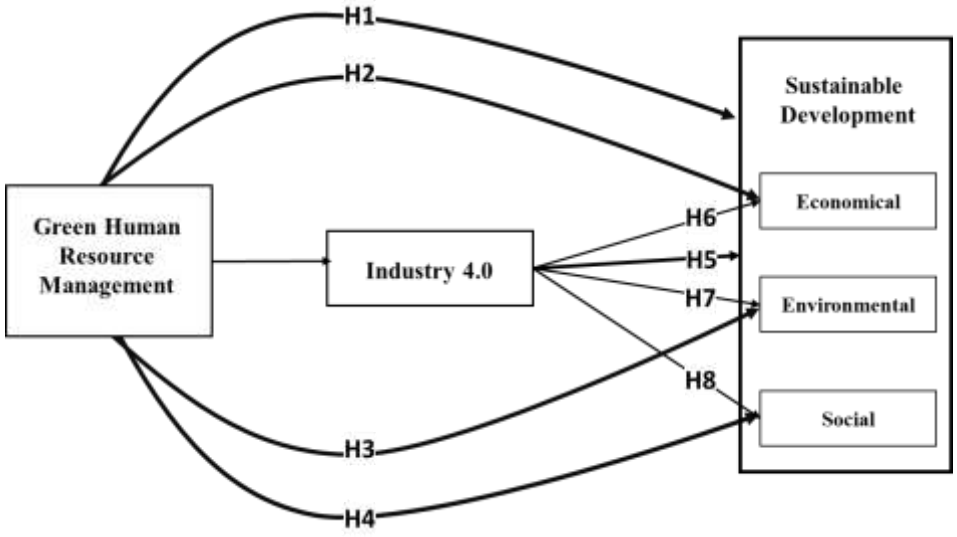

Figure 1: Theoretical Model

Methodology

The descriptive research is used to describe the relationship between the IV (GHRM) and the DV (sustainable development, the triple bottom line view of SD, the economic, environmental, and social perspectives), as well as the mediating role of Industry 4.0.

Research Strategy

A research strategy outlines the plan of action for accomplishing the goals of the study and providing answers to the research questions. Selecting a certain research approach guarantees the study's intended result. Survey research, a methodical approach to gathering data from and about people to characterize, explain, or compare their knowledge, attitudes, and behavior, is used in this study to meet its research aims. (Sekaran & Bougie, 2016)

Extent of Researcher Interference and Study Setting

Since the phenomena were being examined spontaneously, there was very little intervention from the researchers; the only interference occurred when the questionnaire was given to the sample population. (Sekaran & Bougie, 2016). In order to address the research issue, the

study is carried out in an uncontrived context where the observed event occurred in the natural environment, and data for this cross-sectional study is only gathered one time.

Sampling Design and Sample Population

The technical workforce of Pakistani and Middle Eastern aviation companies makes up the study's sample population. Since they work with cutting-edge technology that makes this population's characteristics unique and because no prior study has been done in this particular setting, technical personnel is the most suitable option. In the mentioned region, there are 17 airlines in total. As all civil airlines are obligated by the Chicago Convention of 1944 to follow safety and airline protocols as specified by the International Civil Aviation Organization (ICAO)'s Standard and Recommended Practices (SARPs), results from this sample are adequate for the generalization of outcomes. (ICAO 1944). As the study is conducted on a population size of 17, thus a sample size of 16 is selected for this research (Sekaran & Bougie, 2016). Utilizing simple random sampling, the airlines chosen for this investigation were identified. The unit of analysis in this study was the aviation industry, and the unit of observation was the aviation field experts working for the airline industry.

Data Collection

The study used a quantitative methodology, and online surveys using self-administered questionnaires created on Google Forms were used to gather primary data. Data on every variable may be gathered concurrently from the sample population using the cross-sectional approach (Sekaran & Bougie, 2016). The Likert scale has five answer options, where one represents Strongly Disagree and five represents Strongly Agree. The variables are measured on this scale.

GHRM was gauged by the instrument developed by (Roscoe et al., 2019), identifying that Our company's human resources department looks for candidates who understand the environment; b) when hiring new employees, environmental factors are taken into account; c) environmental education is seen as a critical capital in our organization; d) environmental training is prioritized within the parameters of our business; e) the Human Resources team provides continuous, relevant, and effective environmental education opportunities; f) our human resources department sets a clear, memorable goal for each employee in terms of green practices; g) we

assess staff members' contributions to environmental management; h) the outcomes of personal achievement assessments are recorded in our organization.

The TBL perspective of SD was gauged by the scale developed by (Nara et al., 2020), where the following metrics were used to gauge the economic perspective: a) our profitability has improved as a result of using technology; b) task completion costs have decreased as a result of using technology; and c) energy consumption has decreased as a result of using technology. The following questions were used to assess an organization's environmental perspective: a) Does it employ recycled and renewable resources? b) Has it generated less trash and dangerous materials? c) Has it decreased pollutant emissions? Finally, the following criteria were used to gauge the social perceptiveness of an organization: a) Better working conditions, occupational health, and safety; b) Better employee training and development; c) Better job creation and retention; and d) In terms of community reputation and regulatory compliance, my organization is doing better.

Since Industry 4.0 is a synthesis of several technologies, the technologies chosen were identified by Zafar & Khan, (2024a) as the most relevant one in the aviation field. It was quantified through digitalization, which was done so by asking questions on five different scales and developing a scale produced by (Kotarba, 2017) a) My company employs high-speed broadband to access the internet; b) Video conferencing is used efficiently; and c) Digital forms and documents are used by the company. Second, an instrument developed by (Mikalef & Gupta, 2021) was used to measure artificial intelligence. The results showed that: a) The business can transfer data across organizational and business boundaries; b) My firm has the infrastructure (CPU and GPU power, for example) required to operate artificial intelligence applications; c) Staff members are adequately trained to handle these applications; and d) Our leadership team is skilled at deciding when to use AI.

Last but not least, the instrument created by Amodu and Othman (2018) was used to assess machine-to-machine communication. The results showed that: a) Our organization has the infrastructure to support machine-to-machine communication; b) Our organization uses applications for machine-to-machine communication; and c) Our organization has seamless connectivity of electronic devices for machine-to-machine communication.

Data Analysis

We checked the data for outliers, missing numbers, and disengaged replies after collection. At first, replies from three respondents (out of 277) who had missing data for more than 10% of the total items were removed (Scheffer, 2002). Second, to determine whether respondents were disengaged, the replies' standard deviation was examined. Two respondents were removed from the data set after their replies were carefully examined and their data was validated for extremely low standard deviation. In the end, 292 replies were utilized to analyze the findings.

To test hypotheses, we employ PLS-structural equation modeling. This approach aids in the analysis and assessment of intricate statistical models. Several methods may be used in this procedure to evaluate the structural model's quality. When working with complex models, non-normal distributions, and intricate indicator variables, PLS-SEM is especially helpful in producing usable outcomes. Our study used PLS-SEM for hypothesis testing because of these benefits.

Skewness and Kurtosis. Researchers frequently employ kurtosis and skewness tests to see if data exhibits a regular pattern. Skewness quantifies the degree of distortion in the data distribution, revealing whether or not it is symmetrical. When data is positively skewed, it leans left, and when it is negatively skewed, it leans right. Skewedness indicates that the data is probably symmetrical if it is between -2 and +2. Conversely, kurtosis shows if the distribution contains extreme values. A distribution with low kurtosis has light tails, whereas one with a high kurtosis has heavy tails. Generally speaking, kurtosis levels between -3 and +3 are acceptable (Garson, 2012). These tests assist in ascertaining whether the behavior of the data follows a typical pattern. All of the data that was gathered falls between the ranges of skewness and kurtosis, as Table 1 illustrates.

Table 1
Kurtosis and Skewness of Data

Item	Missing	Mean	Median	Excess Kurtosis	Skewness
DIG1	0	3.144	3	-0.425	-0.179
DIG2	0	3.082	3	-0.973	0.151
DIG3	0	2.938	3	-0.242	0.334
AI1	0	4.103	4	1.664	0.483
AI2	0	4.124	4	1.526	0.614

AI3	0	4.093	4	1.939	0.494
AI4	0	4.082	4	1.761	0.368
MM1	0	2.948	3	-0.422	0.199
MM2	0	2.907	3	-0.609	0.106
MM3	0	2.928	3	-0.693	0.143
ENV1	0	2.845	3	-0.572	0.409
ENV2	0	2.825	3	-0.553	0.205
ENV3	0	2.794	3	-0.707	0.057
ECO1	0	3.175	3	0.198	0.209
ECO2	0	3.165	3	1.153	0.568
ECO3	0	3.113	3	2.681	0.271
SOC1	0	3.062	3	-0.128	-0.296
SOC2	0	3.072	3	-0.466	-0.145
SOC3	0	3.062	3	-0.374	-0.192
SOC4	0	3.072	3	-0.259	-0.074
GHRM1	0	3.804	4	-0.121	-0.067
GHRM2	0	3.474	3	-0.272	0.843
GHRM3	0	3.32	3	1.348	1.51
GHRM4	0	3.567	4	-0.656	0.493
GHRM5	0	3.711	4	-0.534	0.015
GHRM6	0	3.814	4	0.227	-0.295
GHRM7	0	3.845	4	0.858	-0.531
GHRM8	0	3.67	4	-0.922	-0.257

Reliability and Validity. According to Field (2009), a Cronbach's Alpha score of more than 0.5 suffices to show the validity of the instrument used to gather the study's data. Moreover, several investigators have determined that an instrument's exceptional reliability is shown by a Cronbach alpha value greater than 0.7 (Hair et al., 2017; Hair et al., 2018). The next step in assessing the data collecting tool is to ascertain the convergent validity of each concept measure. The degree to which the construct converges to define the variance of its constituents is known as convergent validity. The average variance extracted (AVE) for every item on every topic is used to assess convergent validity. Squaring the loading of each parameter on a construction and computing the mean value yields the AVE. When the acceptable value of the AVE is 0.50 or above, the construct explains at least 50% of the item variation. (Hair et al., 2018). Table 2 demonstrates that all the values to measure the reliability and validity are within the specified ranges.

Table 2
Reliability and Validity

	Cronbach's Alpha	Composite Reliability (rho_a)	Composite Reliability (rho_c)	Average Variance Extracted (AVE)
ECO	0.717	0.746	0.837	0.631
ENV	0.857	0.859	0.913	0.777
GHRM	0.857	0.884	0.89	0.511
IND4	0.904	0.95	0.926	0.602
SOC	0.944	0.947	0.96	0.857

Factor Analysis. In reflective measurement models, the outer loadings denote the strength of the relationship between the indicators and a latent variable. A correlation of at least 0.3 indicates a moderate association between the factors and the items ***(Tavakol & Wetzel, 2020)***. In addition, it is advised to exclude a component from the model if the factor loading is less than 0.2 (Child, 2006). Thus, I eliminated a component associated with Industry 4.0 from my analysis since its loading was less than 0.2. The factor loading values of the items are displayed in the table below, with an emphasis on those having a significant value ($p < 0.5$). Moreover, a factor's T value needs to be greater than +1.96 to be deemed important. Every component included in the study exceeded this cutoff point, demonstrating the validity and importance of each one.

Table 3
Factor Analysis

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
DIG1 <- IND4	0.9	0.899	0.011	82.222	0.000
DIG2 <- IND4	0.854	0.853	0.013	68.072	0.000
DIG3 <- IND4	0.879	0.878	0.013	67.9	0.000
AI2 <- IND4	0.276	0.275	0.049	5.668	0.000
AI3 <- IND4	0.466	0.464	0.054	8.666	0.000
AI4 <- IND4	0.681	0.679	0.032	21.417	0.000
ECO1 <- ECO	0.841	0.842	0.013	62.84	0.000
ECO2 <- ECO	0.795	0.794	0.024	32.797	0.000
ECO3 <- ECO	0.744	0.737	0.055	13.5	0.000
ENV1 <- ENV	0.886	0.886	0.012	74.558	0.000
ENV2 <- ENV	0.866	0.865	0.014	63.862	0.000
ENV3 <- ENV	0.892	0.892	0.01	87.281	0.000
GHRM1 <- GHRM	0.626	0.621	0.044	14.067	0.000
GHRM2 <- GHRM	0.571	0.566	0.067	8.573	0.000
GHRM3 <- GHRM	0.834	0.83	0.029	28.582	0.000
GHRM4 <- GHRM	0.822	0.821	0.024	34.017	0.000
GHRM5 <- GHRM	0.778	0.776	0.029	26.979	0.000
GHRM6 <- GHRM	0.785	0.783	0.028	27.625	0.000
GHRM7 <- GHRM	0.753	0.75	0.038	19.775	0.000
GHRM8 <- GHRM	0.463	0.461	0.063	7.359	0.000
MM1 <- IND4	0.904	0.904	0.008	107.864	0.000
MM2 <- IND4	0.891	0.89	0.01	87.098	0.000
MM3 <- IND4	0.86	0.859	0.016	54.837	0.000
SOC1 <- SOC	0.908	0.907	0.012	72.854	0.000
SOC2 <- SOC	0.925	0.925	0.009	108.091	0.000
SOC3 <- SOC	0.937	0.936	0.007	130.117	0.000
SOC4 <- SOC	0.933	0.932	0.008	116.041	0.000

R^2, F^2, and Q^2 Statistics. After establishing the reliability and validity the R^2, F^2, and Q^2 Statistics of the collected data was established. The Q^2 value above zero is significant and our value of all variables is above zero thus indicating the significance of collected data

Table 4
Q^2 Statistics

	SSO	SSE	Q^2 (=1-SSE/SSO)
ECO	873.000	624.329	0.285
ENV	873.000	362.345	0.585
GHRM	2328.000	2328.000	
IND	2619.000	2512.494	0.041
SOC_	1164.000	630.227	0.459

The R^2 explains the variance in the dependent variable caused by the independent variable. Chin (1998) concluded that an R^2 value of 0.19 indicates weak, 0.33 indicates moderate and 0.67 indicates substantial variance. Similarly, Falk and Miller (1992) suggested that the R^2 value should be higher than the threshold value of 0.1. During this paper, the R^2 values are above the threshold values with Economic as 0.495, Environment 0.759, and Social as 0.537.

Table 5
R Statistics

	R Square	R Square Adjusted
ECO	0.498	0.495
ENV	0.760	0.759
IND	0.056	0.053
SOC_	0.540	0.537

F^2 specifies the change in R^2 if an independent variable is removed from the model and is measured as the effect size which as per Cohen 1988) is large if a value is >= 0.35 large, medium if the calculated value is >= 0.15 medium, and small for value >= 0.02. Our model has values from 0.235 to 1.631, which indicates a medium to large effect

Table 6
F^2 Statistics

	ECO	ENV	SOC_
GHRM	0.350	2.273	1.115
IND	0.845	1.631	0.235

Results

After establishing the normality, validity, and reliability of the data, the hypothesis was evaluated using the PLS-SEM. All of the hypotheses are significant since the p-value is less than 0.05, and T statistics are above 1.96. The results are shown in the table below.

Table 7
The Model with Outcome TBL of Sustainable Development

	Co eff	STDEV	T Statistics	P Values
GHRM ->SD	0.774	0.051	15.121	0.000
GHRM -> ECO	0.431	0.043	10.100	0.000
GHRM -> ENV	0.760	0.039	19.375	0.000
GHRM -> SOC	0.737	0.064	11.517	0.000
GHRM -> IND -> SD	-0.125	0.049	2.564	0.010
GHRM -> IND -> ECO	-0.159	0.058	2.735	0.006
GHRM -> IND -> ENV	-0.152	0.057	2.663	0.008
GHRM -> IND -> SOC	-0.080	0.033	2.392	0.017

The findings have demonstrated a positive relation between GHRM and sustainable development (0.774; P 0.000), showing that there is a 77.4% rise in SD with each increase in GHRM. Therefore **H1** stating that GHRM has a positive impact on sustainable development is **accepted**. A positive relation between GHRM and the Economic perspective of SD is also established (0.431; P 0.000), indicating that an increase in GHRM enhances the Economic perspective of SD by 43.1%, thus **H2** stating that GHRM has a positive effect on the Economic perspective of sustainable development is **accepted**. GHRM has also shown a positive relation with the environmental perspective of SD (0.760; P 0.000) indicating that GHRM practices increase the environmental perspective of SD by 76%, thus **H3** stating that GHRM has a positive impact on the Environmental perspective of sustainable development is **accepted**. Furthermore, GHRM has a positive impact on the Social perspective of SD (0.737; P 0.000) indicating that

GHRM enhances the social perspective of SD by 73.7%, thus **H4** stating that GHRM has a positive impact on the Social perspective of sustainable development is **accepted**. The study has found that Industry 4.0 mediates the relation of GHRM and SD along with the TBL perspective of SD as a suppressor where the mediation and direct effect have different signs (David P. MacKinnon et al., 2000; Tzelgov & Henik, 1991). The coeff values of GHRM with SD, Economic, Environment, and Social, with Industry 4.0 as mediator are -0.1.25, P 0.010; -0.159, 0.006; -0.152, 0.008; -0.080, 0.017 respectively. Thus, **H5** stating Industry 4.0 mediates the relationship between GHRM and the sustainable development; **H6** stating that Industry 4.0 mediates the relationship between GHRM and the Economic perspective of sustainable development; **H7** stating that Industry 4.0 mediates the relationship between GHRM and the Environmental perspective of sustainable development; and **H8** stating that Industry 4.0 mediates the relation between GHRM and the Social perspective of sustainable development are **accepted**. Table 8 gives the summary of acceptance/ rejection of the proposed hypothesis.

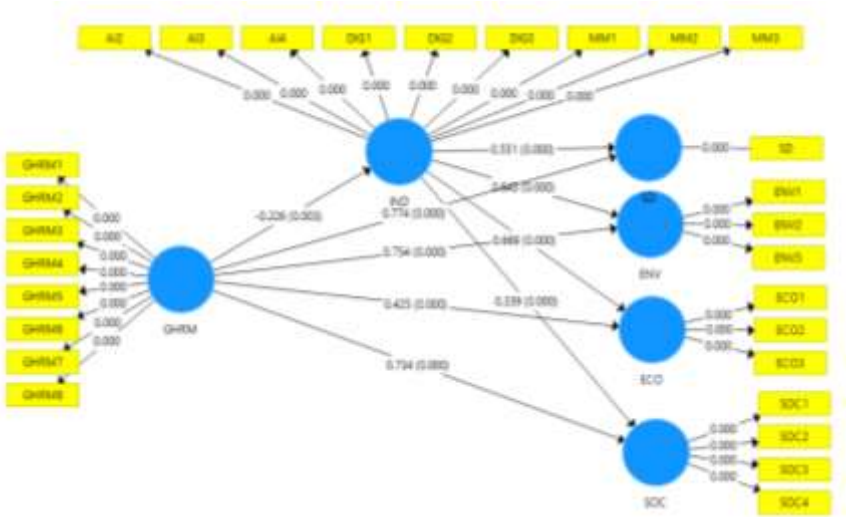

Figure 2: Coeff and p values of the theoretical model

Table 8 Hypothesis Acceptance
Hypothesis Acceptance Table

Hypothesis No	Statement	Result
01	GHRM has a positive impact on sustainable development	Accepted
02	GHRM has a positive impact on the Economical perspective of sustainable development	Accepted
03	GHRM has a positive impact on the Environmental perspective of sustainable development	Accepted
04	GHRM has a positive impact on the Social perspective of sustainable development	Accepted
05	Industry 4.0 mediates the relation between GHRM and sustainable development	Accepted
06	Industry 4.0 mediates the relation between GHRM and the Economical perspective of sustainable development	Accepted
07	Industry 4.0 mediates the relation between GHRM and the Environmental perspective of sustainable development	Accepted
08	Industry 4.0 mediates the relation between GHRM and the Social perspective of sustainable development	Accepted

Discussion

The findings demonstrate a significant and positive relationship ($p = 0.000$) between sustainable development and GHRM which leads to a 77.4% rise in sustainable development. As individuals utilize technology and adjust to changes in the workplace; thus, it is essential that individuals embrace these changes to ensure sustainable development. These results are consistent with the previous conclusions of the studies (Bombiak & Marciniuk-Kluska, 2018; Mukhuty et al., 2022; Zafar & Khan, 2024b; Zubair & M Khan, 2019). Researchers have also found a strong correlation between sustainable business development and GHRM initiatives. According to their research, the more favorably an activity was perceived for its effects, the more often the examined organizations adopted it (Yavuz et al., 2023; Margherita & Braccini, 2023; Ching et al., 2022; Kumar et al., 2023).

We examined the connection between GHRM and the economic component of SD. We discovered a strong and favorable relationship between GHRM and an organization's economic

aspect. The coefficient value of 0.431 indicates that an organization's economic viewpoint of sustainable development rises by 43.1% with an increase in GHRM practices. The study indicates that by promoting efficiency, innovation, and competitiveness within firms, GHRM practices have a favorable influence on the economic dimension of sustainable development. By incorporating environmental considerations into human resource policies and practices, such as hiring new employees, training, and performance management, businesses can reduce resource usage, and waste, and improve operational efficiency. This not only saves money by reducing energy and resource consumption but also fosters innovation in sustainable technologies and processes.

Furthermore, supporting sustainability-related staff training and development contributes to the creation of a trained labor force that can maximize emerging technology and adjust to shifting market needs and environmental requirements. Ultimately, businesses may enhance their long-term financial performance, solidify their position in the market, and promote sustainable economic growth by coordinating HRM practices with environmental aims. These study results add to the body of evidence supporting earlier research demonstrating the beneficial effects of GHRM from an economic perspective (Zafar & Khan, 2024; Carballo-Penela et al., 2023; Shah et al., 2021).

The study has also found a significant impact of GHRM on SD and the environmental & social perspective of SD. These findings are in line with the previous findings as Carballo-Penela et al. (2023) stress the significance of GHRM practices' successful alignment and the many functions that each practice performs to achieve an organization's environmental and financial performance. Employees are actively involved in sustainability initiatives through programs like teaching them about environmental conservation, encouraging carpooling or telecommuting to cut down on carbon emissions, and instituting paperless office rules to conserve resources (Shah et al., 2021). Employers may lower their energy use, trash production, and carbon footprint by encouraging a culture of environmental responsibility and knowledge among staff members. Additionally, green HRM practices help to create a workforce that is driven to adopt eco-friendly behaviors both within and outside of the workplace and that is ecologically conscious. All things considered, implementing green HRM initiatives is essential to reducing environmental effects and increasing sustainable development's environmental component (Carballo-Penela et al., 2023;

Khatoon et al., 2022). According to the study, by encouraging a culture of corporate social responsibility and employee well-being, GHRM practices have a major influence on the social side of sustainable development. Organizations may show their commitment to social responsibility and build confidence among stakeholders by integrating environmental sustainability into HR policies and practices. Additionally, green HRM initiatives support employee happiness and morale, which can result in higher engagement, productivity, and employee retention. Examples of these initiatives include supporting work-life balance, involving employees in sustainability efforts, and offering training on environmental issues (Amrutha & Geetha, 2020; Zafar & Khan, 2024b),.

Industry 4.0 has acted as a suppressor in the mediation role of this theoretical framework. This means that to gain the best results of GHRM for SD, the technology effect has to be controlled otherwise it will weaken the effect of GHRM on SD (Cohen, 1988; Tzelgov & Henik, 1991). This study implies the importance of advanced technologies and how important is the control element of these technologies. According to Oláh et al. (2020), there is an adverse effect on the technology that is affecting the environment, due to air pollution, inadequate waste disposal, and excessive consumption of energy, information, and raw materials. Technology plays a double role and has both its pros and cons. Thus better understanding of technology, especially in the desired industry is of prime importance.

Theoretical and Practical Implications

The findings of this study will serve as a basis for future investigations into sustainable development and methods for ensuring it through the integration of Industry 4.0 and GHRM practices. Practices in GHRM can help guarantee sustainable growth. Therefore, by incorporating ecological concerns into HR procedures and regulations, firms may successfully employ GHRM practices to accomplish sustainable development objectives. For example, increased SD may be the outcome of GHRM activities including staff training on sustainability and environmental awareness as well as the effective and efficient use of Industry 4.0 technologies, thereby reducing the negative impact of advanced technologies that are concentrated on resource efficiency and waste reduction. In addition, GHRM practices may stimulate responsible technology usage and creative solutions to environmental problems by fostering a sustainable culture among staff

members. In the long term, GHRM practices can produce more sustainable results, such as reduced environmental effects, improved CSR, and forge the organization as more competitive in the worldwide marketplace.

The economic benefits of GHRM will encourage the development of sustainable technologies and procedures while lowering expenses and consuming less energy and resources. Additionally, managers may establish a trained staff that can adjust to changing market needs and environmental rules by investing in sustainability-related employee development and training. Ultimately, companies may improve their long-term financial performance, solidify their position in the market, and support sustainable economic growth by coordinating HRM practices with environmental goals. By ensuring these things, managers may show that their companies are socially conscious, which will improve the company's performance and reputation.

Conclusion

In sum, Green Human Resource Management (GHRM) has demonstrated a significant positive influence on sustainable development. By integrating environmental considerations into human resource policies and procedures, organizations can mitigate environmental impacts, enhance corporate social responsibility, and improve competitiveness by fostering a culture of sustainability among employees. Moreover, the potential for achieving sustainable development goals is further amplified by managing the challenges posed by Industry 4.0's advanced technologies. By synergizing GHRM principles with the strategic utilization of Industry 4.0 technologies, organizations can effectively harness innovation to address environmental concerns, increase resource efficiency, and promote sustainable economic growth. The collaborative integration of GHRM and Industry 4.0 creates a synergistic approach with immense potential to advance sustainability and drive positive change in the global marketplace.

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