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Empowering the Women Working in Pakistan's Textile Industries: A Multi-Actor Multi-Criteria Analysis for Sustainability Assessment of E-Health Technologies

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ABSTRACT

While civilized nations around the world are witnessing an unprecedented evolutionary shift towards embracing diversity, equity, and inclusion (DEI), developing societies continue to struggle with deep-rooted socio-economic disparities. Working women in Pakistan continue to face many challenges including health and safety issues in the workplace. This research establishes a decision-making framework for the adoption of electronic health (e-health) technologies among the women in Pakistan's textile industry. It is based on the sustainability assessment of screened e-health alternatives across four domains: technological, environmental, economic, and socio-political. Three stakeholders including the female workers, health practitioners, and policymakers are taken on board for the main phase of multi-actor multi-criteria analysis (MAMCA). There is an interesting variation in the obtained criteria weights among all stakeholders with the highest weights assigned to 'cost-effectiveness' and 'carbon footprint'. Wearable devices have the highest overall ranking apart from policymaker opinions which place it at second rank. Sensitivity analysis ensures the model's robustness which is followed by a validation step using the technique for order preference by similarity to ideal solution (TOPSIS). Obtained rankings of sustainability criteria and e-health technologies can be utilized by a broader range of stakeholders including investors, researchers, female industry workers, industrialists, and DEI promotors.

1. Introduction

Developing compatible products and services for underrepresented groups is an essential step to encourage their participation in mainstream activities across nations, promoting sustainable growth around the globe. One of the main domains for such products is the workplace where the people from these groups work. It is crucial to select and recommend the optimal workplace solutions by

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taking all the main stakeholders on board to ensure long-term inclusive growth from the implementation of diversity, equity, and inclusion (DEI) policies.

One of the main domains for such DEI promotions is the workplaces within the textile industry of Pakistan which has a substantial existence in the worldwide marketplace seeing its distinctive fabric quality, design, and persistent yarn cultivation as researched by Abbas [1]. Aktar *et al.* [2] stated Pakistan was placed in the eighth position among Asia's exporters of textile commodities. Having a segment of 60% of the country's total export income, it employed 38% of the total country's labor force [3]. Although many efforts have been made to neutralize gender bias, it persists as a grey area in the local textile industry. Despite their competitiveness, the female workforce in the textile industry faces numerous work challenges.

The report by the United Nations Development Program (UNDP) states that female technical workers account for 26% of the total workforce while only 2% of women succeed in designating as female legislators, senior officials, and professionals. This accounts for 0.29 of the female-to-male ratio in the textile workplace [4]. To promote women's empowerment in textile workplaces, the background problems affecting their performance should be addressed. The challenges they face include wage disparities, legislation, social security, timing constraints, different types of harassment, irrational workload, bad working environment, and health-related issues [4, 5].

The work-related health challenges encompass several categories. Here are a few instances:

i. Respiratory issues due to workplace air quality.
ii. Musculoskeletal pains due to long work hours.
iii. Psychological distress due to work overload.
iv. Cardiovascular problems due to occupational stress.
v. Poor mental health due to discrimination, night shifts, and overtime.
vi. Physical risks involved due to work shifts.

A scientific approach to addressing the health-related issues faced by these workers is the deployment of e-health technology, empowering them to cope with these challenges. These technologies have recently received the attention of researchers and policymakers all over the world. Reported studies focus on exploring the influencing factors and adoption of respective technologies [6, 7]. However, most of this work has been executed in developed countries and they integrate only a limited number of parameters. Moreover, the developed models mostly address generic health issues and they lack the inclusion of sustainability domains (economic, social, technical, and environmental) in an integrated way [8, 9].

In developing countries, the application of e-health technologies has specific challenges such as the lack of healthcare awareness, irrational distribution of healthcare services, limited funding, resistance to technological change, organizational interoperability, inadequate ICT infrastructure, and misconceptions about the gadgets. In some cases, psychological, social, legal, and ethical issues may also create challenges to the long-term adoption of e-health in developing nations [10].

Sustainability assessment of e-health technologies is challenging because of the complexity of healthcare systems, the rising demand for resources, and the absence of the concept of sustainability in the healthcare field [11]. Fanta and Pretorius [12] developed a framework for sustainable e-health implementation which provides the technological agenda specifically for developing countries. The study examines the impact of certain factors on the long-term adaptability of e-health solutions. Alajlan and Baslyman [13] suggested that process integration and systems integration are the two significant objectives to ensure the sustainability of healthcare information systems for e-health gadgets.

A crucial part of the successful implementation of e-health technologies is the efficient handling of the rescored patient data. The focus of the work presented by Shabo [14] was the sustainability of electronic health records (EHRs). The author evaluated the sustainability challenges of three distinct EHR models from the perspectives of management, law, and technology. The work highlighted the semantic interoperability standards, patients' bills of rights, conflicts of interest, and access limitations in certain specific instances.

One issue with the existing literature on the implementation of e-health technologies is that it mostly addresses the generic health problems of society. For instance, the study conducted by Dione [15] proposed an Internet of Things (IoT) based model for developing countries by examining the current status of e-health technology and its evolution over the years. However, the model is generic for the overall society. Cesarelli *et al.* [16] explained the implementation of e-textiles for the biomedical and clinical sectors. They reviewed the application areas for e-textiles including medicine and other sectors along with testing of various e-health gadgets. Although their work focuses on specific e-health products, it is presented from the perspective of general society.

Only a limited amount of research work is reported in the literature which specifically focuses on targeted industrial segments for e-health implementation. An example of the assessment of technological solutions for the banking industry is the study conducted by Nejad *et al.* [17] which proposed a technology-based management tool by intervening three independent models for assessing social sustainability. However, most of the similar models have not worked on exploring e-health technologies for specific groups.

For complex circumstances where we have a wide variety of available e-health alternatives and a large number of influencing criteria, a scientific solution is to prioritize the factors and alternatives using the tools from the domain of multi-criteria decision-making (MCDM). Such tools have, therefore, been utilized by many researchers around the world. There are many MCDM applications in the e-health segment as well. A comprehensive literature review has been compiled by Mumtaz [18] on overall decision-making tools used to address e-health solutions. Kelley *et al.* [19] evaluated the MCDM system for its compatibility with health technology assessments.

Among MCDM techniques, the analytic hierarchy process (AHP) is a very popular one mainly due to its accurate pairwise comparisons, versatility, and powerful back-end mathematics [20, 21]. It has been used in many applications of industrial decision-making [22, 23]. A specific example of such applications is the study presented by Rajak and Shaw [24] which deployed AHP and fuzzy-technique for order preference by similarity to ideal solution (TOPSIS) for evaluation of mobile health applications. Seh *et al.* [25] established an e-health model using AHP, TOPSIS, and fuzzy logic to identify and classify barriers to e-health in India.

In another recent study by Mohammadzadeh and Raayatpanah [26], Iran's e-health system has been prioritized using AHP. It has also been used to develop the sustainable supply chain of the e-health sector [27]. These studies provide a few examples of the scientific contribution of AHP in terms of solving e-health problems at the national level.

Multi-actor multi-criteria analysis (MAMCA) is an extended version of the MCDM that assembles the perspectives of various stakeholders in diverse settings [28]. Although one can hardly find any MAMCA application in the e-health sector, the usage of this concept in other domains like sustainability services [29], transport appraisal, logistics [30], and electrification [31] is quite interesting and promising. In addition to handling a wide variety of parameters and alternatives, MAMCA enhances traditional MCDM methods by involving the respective stakeholders both individually and collectively.

Overall, it can be concluded from the sample of relevant literature presented that most of the reported work is limited to general e-health implementation issues in society. It does not consider a wide range of influencing parameters from the main domains of sustainability including social, environmental, economic, and technical. Moreover, the reported studies mostly overlook the involvement of multiple stakeholders. The problem of sustainability assessment of e-health technologies for female workers in the textile industry is, therefore, novel and practical. There is a clear research gap in MAMCA applications in the e-health segment, particularly in the case of female workers in the textile industry. These workers can be empowered in their workplaces by offering the most compatible e-health technologies considering a broader range of influencing parameters and taking all the stakeholders on board. Under the light of explored research gaps, this study proposes a MAMCA-based decision model for the exploration and prioritization of e-health technologies for the mentioned group of workers in their workplaces. Thus, the overall aim of this research is to empower these female workers by prioritizing e-health technology alternatives and parameters using MAMCA. To attain this aim, the following research objectives have been recognized:

i. Identify the main stakeholders involved in the selection of e-health solutions for female workers in the textile industry.
ii. Explore the e-health gadgets and influencing parameters from the sustainability domains (technical, social, economic, and technical) associated with the textile industry workplace.
iii. Prioritize the screened parameters and rank the alternatives using the real-world data collected from all the main stakeholders.

Based on the novelty and significance of the study discussed above, the next section entails the methodology implemented for attaining results.

2. Materials and Methods

In this section, an explanation of the overall methodology used to complete this research is presented. The research approach is broken down into four distinct phases, each of which is shown in Figure 1.

The ‘Initialization’ phase reviews primary health issues, sustainability parameters, and gadget alternatives. This initial screening includes an extensive literature review and deliberations with stakeholders, especially the female workers. A comprehensive review of MCDM techniques applied to similar health problems and the respective research gap analysis is also a part of this phase. The output of the first phase is a preliminary list of alternatives (gadgets) and the criteria influencing the selection of these alternatives.

The ‘Designing’ phase comprises the identification of stakeholders and a rational screening of the preliminary alternatives and parameters (criteria), thus designing their standardized hierarchy to be analyzed in the main MAMCA phase. The screening of parameters and alternatives is conducted through a literature review, deliberations with the stakeholders, and distribution of an initial questionnaire. This phase also includes the designing of pairwise comparison matrices as questionnaires, to be filled in by the stakeholders.

Phase 3 is the main part of this research in which the MAMCA is performed. The data is collected from three stakeholders including female workers in the textile industry, health practitioners, and policymakers. The developed mathematical models are solved in respective software which also includes a thorough sensitivity analysis. TOPSIS is also applied to separately collected data to reinforce the reliability of MAMCA results. This phase produces a prioritized list of criteria and a ranking of the e-health gadgets for female workers in the textile industry. Results obtained from model solutions are presented in Phase 4. This includes a detailed discussion of MAMCA results, the TOPSIS results, and sensitivity analysis.

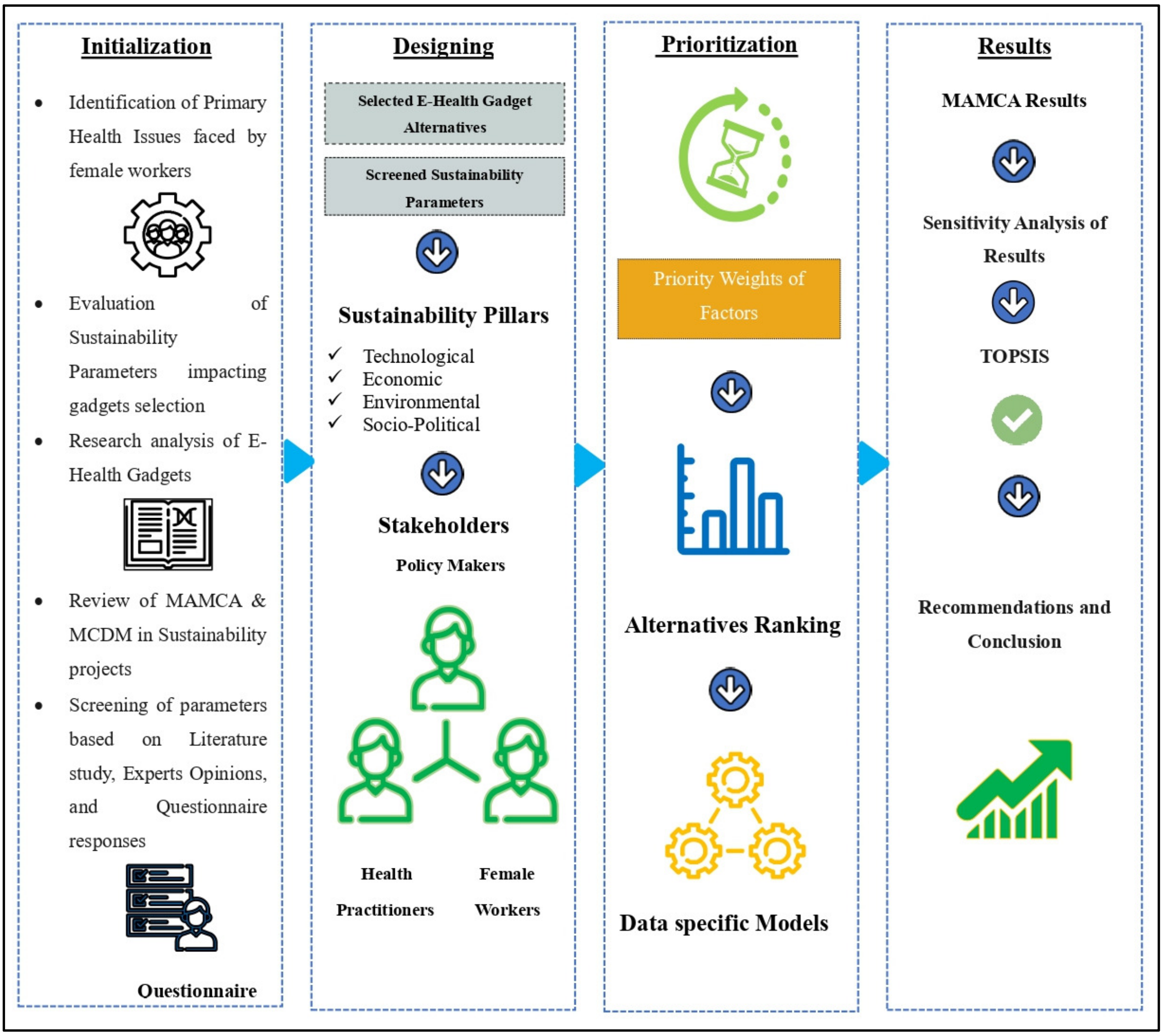

Fig. 1. Development of the decision model

With the MAMCA, one can explicitly take the objectives of complex projects into account and come to a good overview of the advantages and disadvantages of different options. AHP is applied from the perspectives of different stakeholders and the aggregate priority weights and rankings are eventually computed. Results are eventually presented in the form of multiple actors (stakeholders) and 'as a whole'.

3. Screening of E-Health Alternatives and Relevant Parameters

This section provides a discussion on identified e-health alternatives and their respective influencing criteria in the context of back pain issues female workers faced by them in their workplaces within the textile industries.

3.1. E-Health Technology Alternatives

E-health gadgets for workers vulnerable to back pain issues during their work hours in the textile industry are introduced in this section. E-health gadgets, also known as electronic health gadgets, are devices designed to monitor health and facilitate the management of personal well-being. These gadgets encompass a wide range of technologies, from wearable devices to mobile applications and other specialized monitoring tools. E-health technology is specified for back pain and is comprised of digital devices, wearable widgets, and online health platforms.

An initial list of alternatives for back pain issues of the women working in the textile industry was explored from literature and deliberations with the health practitioners in the selected textile industry (Table 1). These e-health alternatives can operate via online portals or through in-person meetings. Using these gadgets, female workers can easily monitor their back pain issues whenever they flare up, allowing for a remedial plan to be constructed.

An initial meeting was held with a group of women representing the target population and the healthcare professionals. Through a collaborative discussion, a consensus emerged to include four potential alternatives for rigorous evaluation in the next research phase. These alternatives include mobile applications, wearable devices, 24-hour remote monitoring, and telehealth Web portals. The screened alternatives are briefly introduced here.

Table 1
Initial list of explored e-health technologies

E-health technologies	Literature references
Mobile applications	**[32-37]**
Wearable devices (detectors, sensors)	**[38-49]**
Online visual sessions	**[50-53]**
Telehealth Web portals	**[54-59]**
IoT-based remote pain monitoring systems	**[60]**
Telephone connectivity	**[61-63]**
24-hour remote monitoring (in-home monitoring)	**[64-67]**
E-mail correspondence	**[68-70]**

3.1.1. Mobile-Health (m-Health) Applications

Mobile applications are intended to assist and improve healthcare delivery using mobile devices by featuring medical information and providing illness-specified information. Various mobile applications accessible through both Android and iOS devices, work for psychological treatment including cognitive behavioral therapy and self-monitoring of patients having backache [71-73]. There are several smartphone applications designed for people with back pain. They can be used in conjunction with email contact from health professionals and SMS reminders [74, 75]. Female workers can utilize these mHealth apps for back pain management as they monitor and assist individuals suffering from acute or chronic pain providing them with timely updates about their condition and helping them manage their pain. These mHealth apps can be assessed online or purchased for chronic back pain.

Mobile apps specified for back pain people are designed because of users' requirements. These mostly provide education about users' health, offer exercise schedules, and psychological interference [76]. The output results or suggestions provided by these apps may involve muscle stretching and strengthening techniques, exercise plans, and suggested yoga to ease back pain. However, some apps prescribe using medicines, remaining active, and doing postural therapy and aerobic exercises. Manual therapy, mindfulness, cognitive behavioral therapy, and lifestyle guidance are also some m-Health means recommended by these apps for specific requirements of the workers.

3.1.2. Remote Monitoring

A type of telemedicine called remote monitoring (RM) employs technological instruments to monitor gadget user data outside of conventional medical facilities. Remote monitors have become popular e-health gadgets, especially for in-home evaluation of back pain issues or other musculoskeletal problems [77, 78]. This technology is intended to help people manage and track their health issues by delivering real-time data and feedback. Using real-time user data, RM enables medical personnel to modify treatment programs and continuously monitor user's pain levels. This may lessen the need for frequent in-person visits, help users manage their pain more effectively, and maybe lessen the effects of chronic back pain.

By giving people access to pain remedies, RM can assist people in managing their pain in addition to tracking pain signals. Workers can determine what relieves their pain the most and modify their treatment plan as necessary by monitoring the results of various treatments. Workers can lessen their reliance on painkillers and other prescription pain relievers, which might have unfavorable side effects, by receiving continuous assistance and pain treatment [79]. Backache patients can set objectives and progressively improve their activity levels under the supervision of healthcare specialists by measuring these metrics, which can benefit their rehabilitation and general well-being [80-82].

3.1.3. Telehealth Web Portals

Telehealth online portals may be an excellent source for controlling and seeking treatment for back pain patients. These portals offer a digital platform via which patients may communicate with healthcare providers remotely [83]. Individuals suffering from back pain can make virtual appointments with healthcare experts who specialize in treating back problems using telehealth web portals. Women working in the textile industry can discuss their symptoms, receive advice on self-care practices, and obtain exercise prescriptions or physical therapy suggestions that are specially customized to their requirements during these meetings [84, 85].

These portals frequently incorporate video consultations, encrypted chat, and document-sharing capabilities, allowing their users to submit pertinent medical data or diagnostic pictures. This not only improves the ease of remote healthcare but also improves the quality of care. There are several web-based telemedicine solutions accessible for back pain patients. These may be used in conjunction with different telehealth portals to provide remote treatment for back pain conditions. Additionally, several web-based telemedicine options are available. These can be utilized to treat back pain disorders remotely in combination with various telehealth websites. The simplicity, accessibility, and personalized nature of this e-health alternative eventually contribute to the successful management and treatment of back pain of female workers.

3.1.4. Wearable Devices

These are electronic devices that are worn on the body and in the form of wristbands, smart watches, or clothes with built-in sensors and connections [39]. One of the key functions of wearable E-health devices is to collect health and well-being data [40]. For a range of therapies and medical treatment for backache, these devices can be frequently utilized alongside visual and/or in-person treatment. Some of the wearable sensors include body-worn smart clothing, wearable fitness trackers, lift activity trackers, and bio-mechanic behavior recorders. Wearable sensory technology allows for the remote monitoring of many medical parameters using a small wearable device. It supplies information to a database that may be seen locally on a phone or online by the user and clinician [86-88].

An example of WDs is the smart back-belt or lumbar support brace that combines sensors to monitor the workers' movement and posture. It can offer real-time feedback on inappropriate motions or excessive back strain, assisting female workers in avoiding activities that may heighten their back discomfort.

3.2. Influencing Parameters

The decision of alternative ranking depends on a wide variety of influencing parameters from the sustainability domains including technical, economic, social, and environmental. Exploring and preparing a comprehensive list of such parameters is a prerequisite for MCDM work. As a first step, a preliminary list of parameters was prepared through a literature review and was presented to the female workers and policymakers in a general session formally arranged at the selected textile factory. This list along with literature references is presented in Table 2.

Table 2
Preliminary list of identified parameters

Parameters	Reference	Parameters	Reference
Availability of infrastructure	**[89-92]**	**Sensors**	**[107]**
Efficiency	**[93-95]**	**Disposal management**	**[95, 98, 106, 108]**
Carbon footprint	**[96, 97]**	**Service quality**	**[95]**
Expectation	**[98]**	**Economic benefit**	**[109]**
Convenience	**[94, 97, 99-105]**	**Sustainability**	**[90, 92]**
Performance	**[98, 106]**	**Reliability**	**[110]**
Cost-effectiveness	**[94, 96, 97, 100, 103]**		

Eventually, the list along with initial feedback from the female workers was presented to a group of policymakers for detailed deliberations and screening. After a few discussion sessions, some of the factors were found to be less relevant to the prevailing circumstances of the selection decision. Table 3 presents the final list of screened parameters, their brief description, and general mapping with the alternatives.

Table 3
Screened parameters

Parameters	Description	Preferred characteristics associated with alternatives
Convenience	**How convenient do the workers feel while using the selected e-health tool?**	**A convenient alternative is preferrable**
Cost-effectiveness	**Is the selected e-health technology cost-effective? It needs to be affordable as well as efficient**	**Alternative with least cost would be preferred (Higher values are undesirable)**
Security	**Is the e-health technology secure in terms of the digital safety of data and personal information?**	**Secured e-health solutions are desirable**
Carbon footprint	**Environmental impact associated with count of emissions while using respective e-health technology**	**Higher values are undesirable**
Service quality	**The level of overall support delivered to the users regarding E-Health technology**	**Higher values are desirable**

The formal AHP hierarchy of the problem with screened parameters and alternatives is presented in Figure 2.

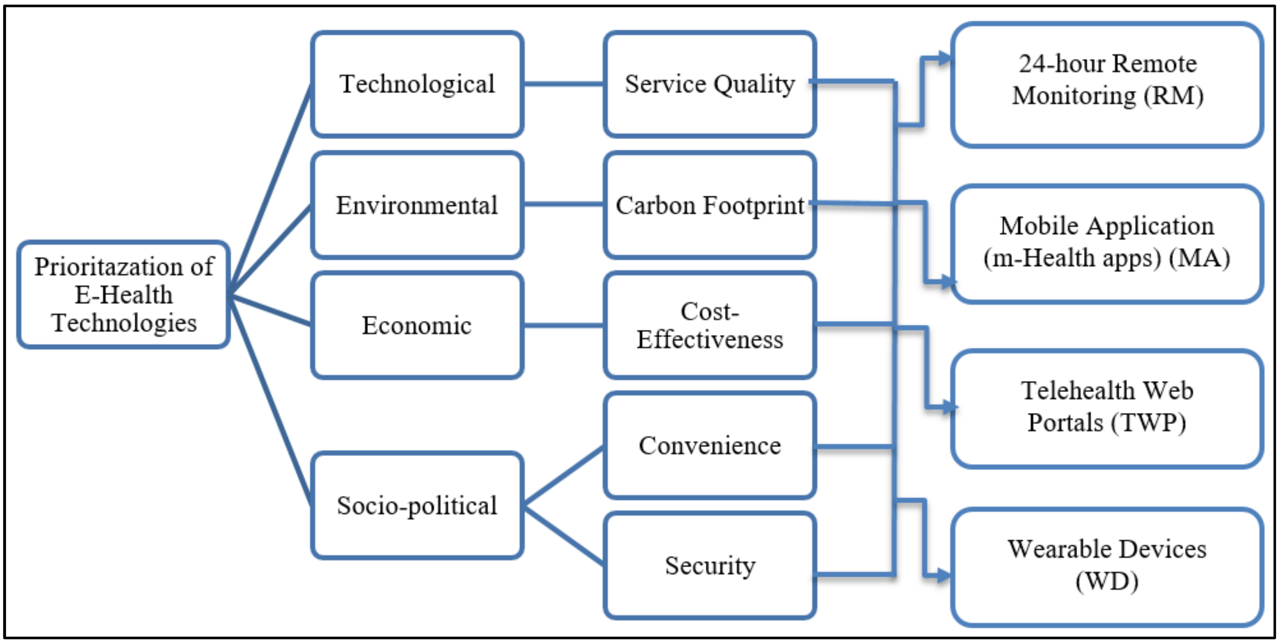

Fig. 2. Hierarchical model of the decision problem with screened parameters and alternatives

4. Results and Discussions

This section presents a detailed discussion of the results obtained from data-specific model solutions. The AHP hierarchy is transformed into questionnaires that are comprised of pairwise comparisons. The main targeted respondents of this questionnaire were the female workers of the mainstream textile industry of Pakistan. The same questionnaires were also sent to the health practitioners associated with this industry and the policymakers responsible for major textile industry decisions. The data collected in several months become input to the MAMCA and TOPSIS models. Results obtained from these models along with a detailed sensitivity analysis are presented in upcoming sub-sections.

4.1. Multi Actor Multi-Criteria Analysis

Data-specific models were designed in respective software. The procedure encompasses the creation of the final list of factors that influence e-health gadgets as well as the alternatives. Table 2 and Table 3 elaborate on these shortlisted factors impacting e-health gadgets selection.

Unlike the traditional AHP, which records the opinion of a certain group of experts, MAMCA facilitates the inclusion of various stakeholders to develop a reinforced and concurrent decision support system. The pairwise precedence evaluations of all criteria for each other, as well as all alternative solutions to each criterion, are recorded stakeholder-wise. Models are developed and analyzed based on pairwise comparison through the AHP Software. Inconsistencies in each result module are ensured to be less than 0.1. The findings are compiled in two forms: stakeholder-wise parameter priority weights and gadget alternative rankings.

Figure 3 depicts the weights obtained for criteria in the context of stakeholder opinions. It further entails the aggregate results yielded by cumulating three stakeholders. The computed priority weights from the recorded stakeholder opinions provide some very interesting results (Appendix).

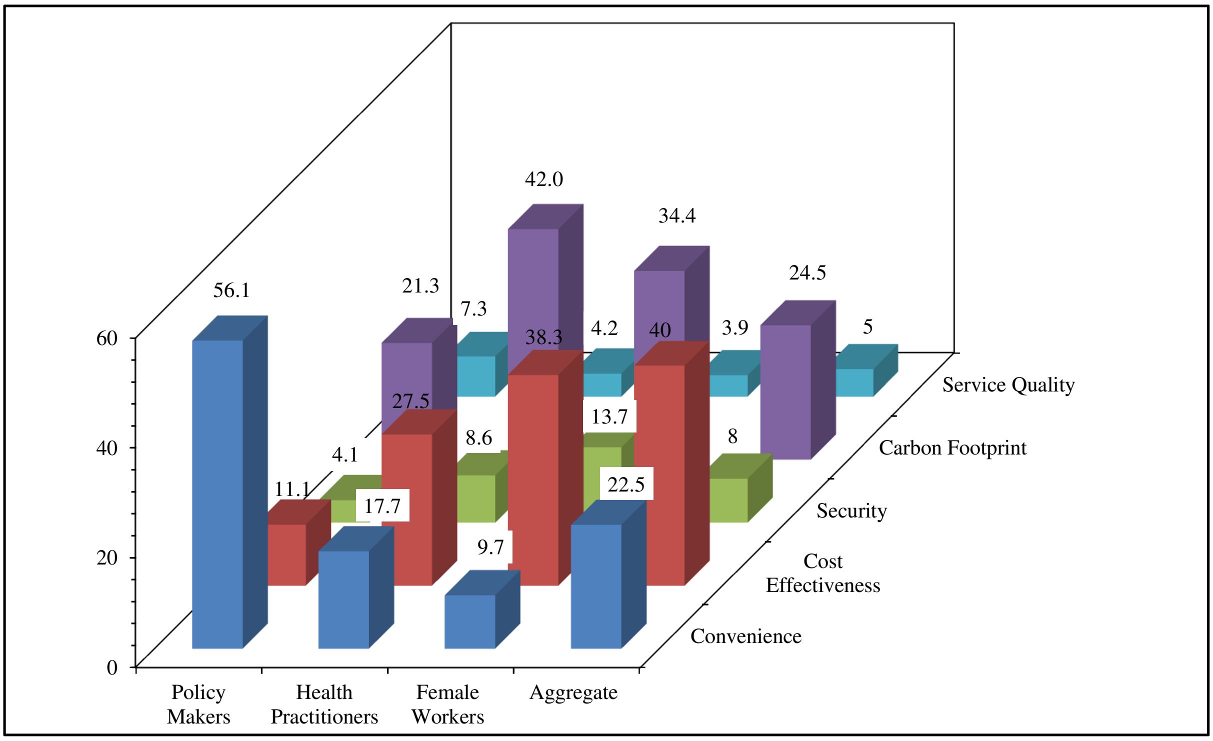

Fig. 3. Stakeholder-wise priority weights of influencing parameters

Because of policymakers, convenience' received the highest priority weight with a normalized score of 56.1. Carbon footprint was computed as the second most important criterion with a score of 21.3. Cost-effectiveness was ranked the third most important criterion with a score of 11.1. The policymakers placed the 'service quality' at the lowest position on the list. It is interesting to note that despite being in a developing country, the policymakers in Pakistan gave a higher priority to the environmental factor (carbon footprint) over the cost-effectiveness.

Conferring to the stance of health practitioners, carbon footprint ranked top among the other criteria with a normalized score of 42 followed by 'cost-effectiveness' which received a score of 27.5. Convenience and security are the next two factors in the priority list of health practitioners. These stakeholders are not very concerned about the service quality of the adopted e-health gadgets. Once again. It is encouraging that this group of stakeholders assigned the highest priority weight to the carbon footprint which is associated with the clean ecosystem in the country and the planet.

The female workers of the industry have a slightly different perspective on the importance of criteria. They gave the highest priority to cost-effectiveness, which received a normalized score of 38.3. However, interestingly, the carbon footprint was ranked as the second most important criterion with a score of 34.4 which was very close to cost-effectiveness. It was highly encouraging that these workers were quite concerned about environmental issues. They majorly belong to the lower middle segment of society and the results obtained through their recorded perspectives demonstrate their financial preferences.

The aggregate results placed cost effectiveness at the top, followed by the carbon footprint and socio-political factors respectively. These results are interestingly quite close to the stance recorded by the female workers. Overall, it can be concluded that the priorities assigned by the three stakeholders suggest a significant importance of the economic and environmental parameters while the socio-political factors received some variations among the stakeholders.

Figure 4 presents the stakeholder-wise ranking of the e-health gadget alternatives. There seems a consensus among the opinions of health practitioners and female workers as they have assigned higher weights to the wearable devices in comparison to other gadgets with a normalized ranking score of 41.2 and 38.1, respectively. Policymakers prioritize wearable devices as their second preferred gadget alternative with a score of 19.2. This alternative is user-friendly, economical, as well as convenient in all conditions. The priority weight assigned by the health practitioners to WD is higher than the female workers. This can be linked with more awareness regarding the practicality of such devices.

Mobile health applications are prioritized foremost by the policymakers, due to their practicality, receiving an overall normalized score of 58.0. However, policymakers assigned much lower priorities to the rest of the alternatives as compared to MAs. Health practitioners have given a second priority to MAs with a score of 31.7 while the female workers have assigned a score of 36.2 to them.

The aggregate MAMCA results show that the wearable devices have secured the topmost position in the ranking list followed by the 'mobile applications', and 'remote monitoring', respectively. Telehealth Web Portals could not get any significant attention from all the stakeholders.

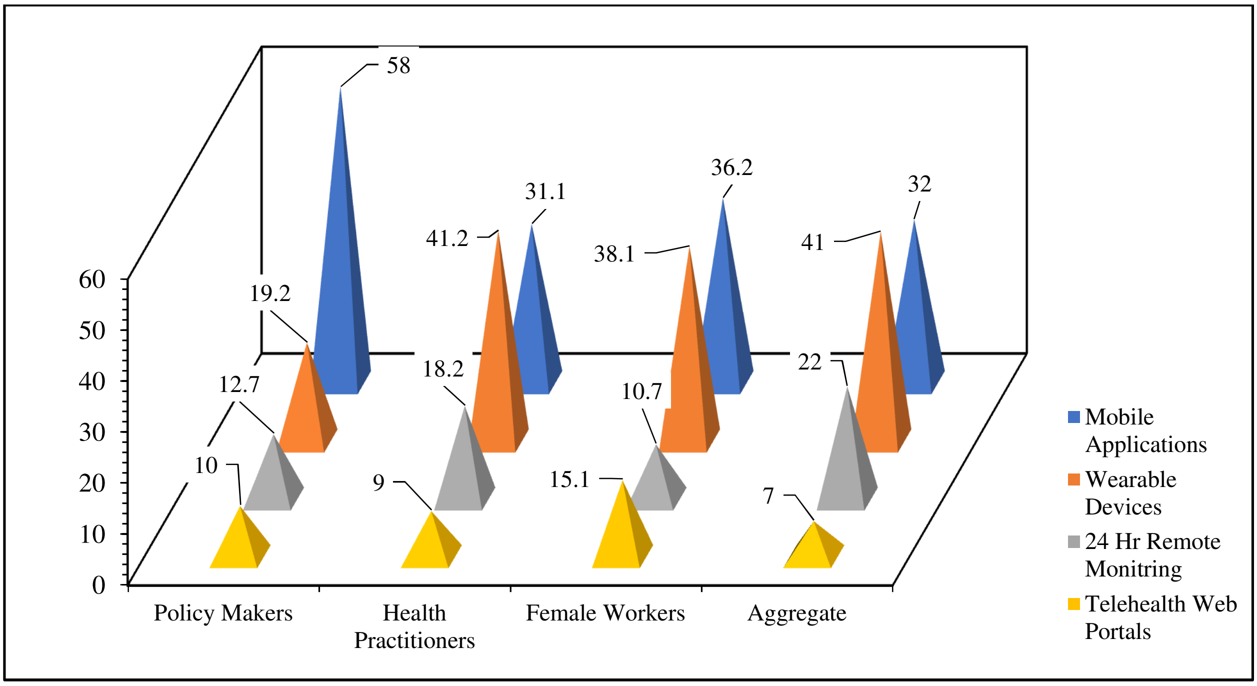

Fig. 4. Stakeholder-wise priority weights of alternatives

4.2. Sensitivity Analysis

Computed alternative rankings are a function of the assigned priority weights. Any variations in the relative weights of the input factors may affect the overall rankings of the e-health alternatives. In this sub-section, input parameters, one at a time, are artificially assigned the higher priorities and the resulting alternative weights are monitored. Figure 5(a) includes the original results to ensure convenience in result interpretations. Figure 5(b)-(e) demonstrates the detailed results of this sensitivity analysis performed on three stakeholder perspectives separately as well as on the aggregate results. The horizontal axis presents different criteria, whereas the vertical axis shows their respective relative weights. The third axis represents the alternatives. In each case, the weights of four criteria are given the highest priorities one by one, and their effects on the alternatives are recorded.

While the general pattern of the aggregate results after sensitivity analysis almost matches the original results, some notable deviations are observed in the viewpoints of different stakeholders.

However, the top two alternatives (wearable devices and mobile applications) remain at the top in almost all cases. Overall, it can be concluded that the models are robust with a few minor exceptions.

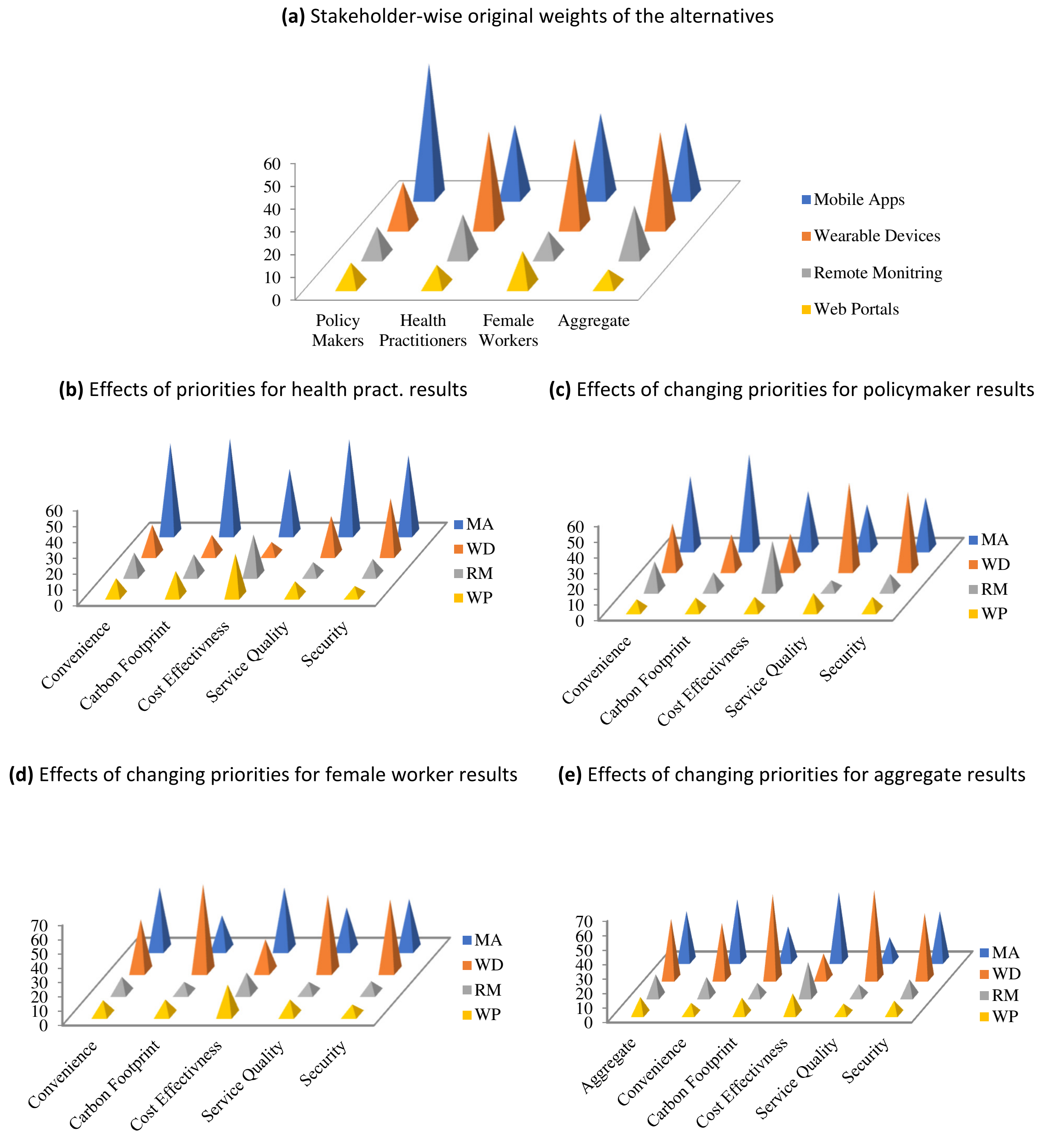

Fig. 5. Effects of changing priorities

4.3. TOPSIS to Validate the MAMCA Outcomes

The decision to establish the final stakeholder-wise ranking list of e-health alternatives is quite complex. It is, therefore, reasonable to validate the results using another method. For this purpose, TOPSIS was used in this study. The newly designed questionnaires, according to the standard TOPSIS format, were sent to some of the experts from the top management of the textile industry. It was ensured that these experts did not participate in the initial MAMCA phase and were not aware of the initial MAMCA ranking. The results obtained using TOPSIS are summarized in Figure 6 and their comparison with the MAMCA results is provided in Table 4.

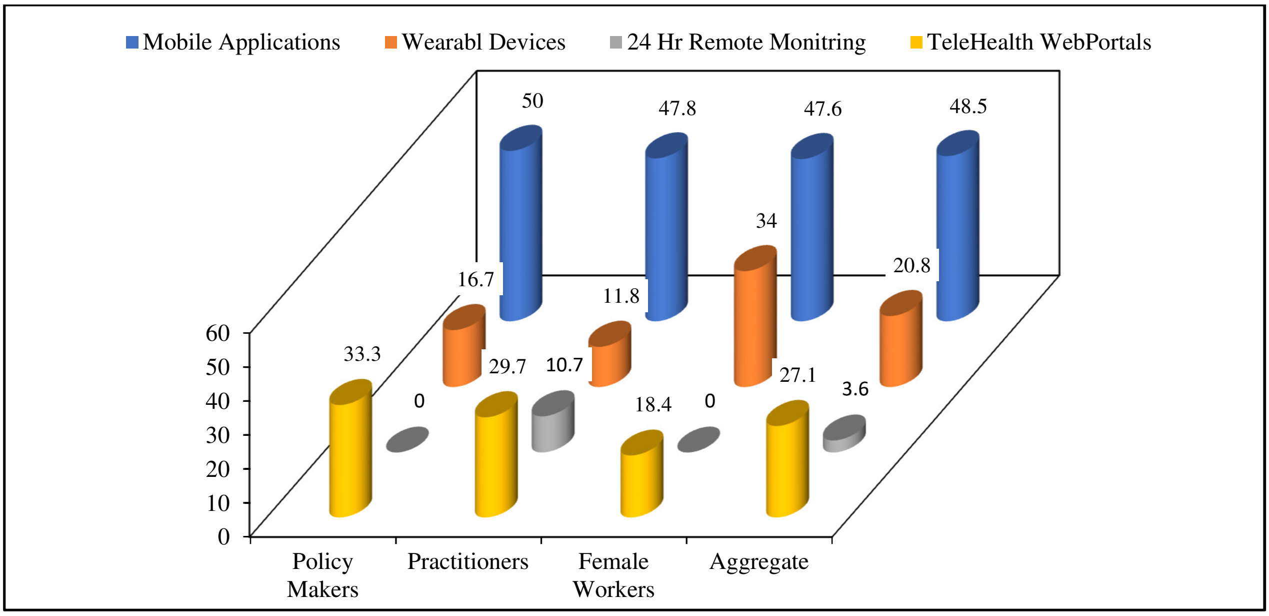

Fig. 6. TOPSIS ranking

Both methodologies have mostly placed mobile applications at the top of the list except for the perspectives of practitioners and female workers who place wearable devices on top in the main results of MAMCA. Remote monitoring received the lowest weight in TOPSIS, and it is at the second-last position in MAMCA. In the big picture, it can be concluded that the TOPSIS results endorse the MAMCA results.

Table 4
Comparison of MAMCA and TOPSIS alternative rankings

Actors	MAMCA				TOPSIS			
	MA	WD	RM	TWP	MA	WD	RM	TWP
Policymakers	**58.1**	**19.2**	**12.7**	**10**	**50.0**	**16.7**	**0.0**	**33.3**
Practitioners	**31.2**	**41.7**	**18.1**	**9.0**	**47.8**	**11.8**	**10.7**	**29.7**
Female workers	**36.2**	**38.1**	**15.1**	**10.6**	**47.8**	**18.4**	**0.0**	**34.1**
Aggregate	**41.8**	**33.0**	**15.3**	**9.9**	**48.6**	**15.4**	**3.6**	**32.4**

5. Conclusions

In developing countries such as Pakistan, there are many groups which have minimal representation in the mainstream national activities. Although female workers are encouraged to join textile industries due to the demands of international certification bodies, they face numerous health and safety challenges in the workplace. This paper is an effort to propose a decision framework for the adoption of e-health technologies among these workers. It screens and prioritizes four technology alternatives, and five criteria related to the four pillars of sustainability under the perspective of three stakeholders, including female workers.

Outcomes from the parameters section of the MAMCA portrayed an interesting picture of different priority weights. There is a clear difference in the opinions of the three stakeholders for the topmost parameter. Policymakers give the highest weight to convenience, while health pretensioners and female workers place the carbon footprint and cost-effectiveness at the topmost position in the priority list. Service quality is not very important from the perspective of all three stakeholders. In aggregate, cost-effectiveness, convenience, and carbon footprint are the most crucial parameters, respectively.

Wearable devices are ranked as the best e-health gadget for female workers in the textile industry, from the perspective of health practitioners, and female workers. However, the policymakers gave the highest ranking to mobile applications. Telehealth web portals and remote monitoring did not receive significant attention from all three stakeholders. From the aggregate results, it can be concluded that there is a consensus among the stakeholders that wearable devices and mobile applications are the first and second alternatives, respectively, in the ranking list. Sensitivity analysis endorses the model's robustness and TOPSIS is used to validate the results.

It is pertinent to mention that the model outcomes of this study are based upon the data collected from a single textile industry in Pakistan where female workers, being a less represented group, face unique challenges. Policy implications may vary in different parts of the world and some other modern gadgets can be considered. The developed models can be modified and reused for the other DEI segments around the globe to prioritize more products and services.

Appendix: Stakeholder-wise matrix of computed weights for criteria

Main criteria	Sub-criteria	Policymakers	Practitioners	Female workers
Technological	**Service quality**	**7.3**	**4.2**	**3.9**
Environmental	**Carbon footprint**	**21.3**	**42**	**34.4**
Economic	**Cost-effectiveness**	**11.1**	**27.5**	**38.3**
Social	**Convenience**	**56.1**	**17.7**	**9.7**
	Security	**4.1**	**8.6**	**13.7**

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Conflicts of Interest
Authors declare no conflict of interest in the publication of this research.

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