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Qualitative mapping of barriers to the renewables' development against energy literacy dimensions: A case study of Pakistan

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Abstract

The development of renewable energy (RE) has been recognized as a promising way for solving the energy security problems in future. However, there are various barriers that hinder the development of RE. The awareness of the decision-makers about these barriers can lead to designing the appropriate strategies for overcoming them using the focused index of energy literacy. Energy literacy is a critical component of the fourth sustainable development goal (SDG) for achieving social aspect of energy security (SDG-7). The purpose of this effort is to emphasize the critical nature of energy literacy in tackling the challenges to RE development. Thus, the barriers to the RE development in Pakistan are defined and classified according to their political, economic, social, technological, environmental, and legal dimensions. By holding focus group meetings with energy and outcomes-based education (OBE) theory specialists, these barriers are mapped with dimensions and sub-dimensions of energy literacy. The analysis of qualitative mapping reveals that the affective dimension of energy literacy is critical for overcoming the majority of the barriers encountered. It is manifested that energy literacy can play a critical role in building a sustainable future by positively tackling the barriers.

1. Introduction

The term 'sustainability' associated with sustainable development goals (SDGs) refers to the strategies that could lead to the improvement of education, health, reduced inequality, economics, and climate change sectors. The key linkage among these seventeen SDGs is assigned to SDG-7 (clean and affordable energy) that is measured in terms of energy security, energy poverty mitigation, and climate change aspects [1]. The attainment of SDG-7 is regarded critically important for people of the planet which is not possible without their involvement especially of the poor community. Even so, energy crises are labeled as humanitarian crises as power shortfall could lead to the emergence

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of multiple social evils [2]. Thus, SDG-7 is not only an alone entity but also has significant impacts on the society concerned elements of other SDGs.

The accomplishment of the SDG-7, which is contingent on a sustainable energy transition that increases the share of RE in the energy mix, is hampered by a variety of barriers [3]. The solution of any certain type of barrier is associated with confronting entity such as human which is the prominent reason for the barriers due to the lack of awareness especially in developing nations [4]. Every individual is equally important and responsible for getting educated about it. To advance the understanding of energy issues with the objective of overcoming barriers, it is critical to identify the human nature perspective(s) that correlate to a particular type of barrier [5]. The answer can be drawn through energy literacy (an aspect of SDG-4) dimensions under the flag of out-comes based education (OBE) system [6]: a Washington Accord governed education theory to substantiate the viability of education. The definition of the energy literacy is still a debating matter, but it usually can be defined in terms of three aspects [7]: *knowledge* about the energy resources, technologies, and production, *attitude* of consumption and adoption of modern energy resources, and *behavior* towards energy efficiency and savings actions. There is currently no well-defined scale for determining one's energy literacy [5]. However certain studies reported that achieving a high level of energy literacy is more concerned with the behavioral change and attitude of the people towards energy applications rather than the knowledge only [8].

Insight of the barriers to renewable energy (RE) development, there is a list of factors identified by multiple researchers (as mentioned in Section 3), and different policy implications have also been proposed accordingly to address them. Meanwhile, 'human' is the only viable element to make the policy suggestions to get endorsed. To fulfill SDG-7's targets and make the world more sustainable, human participation in a correct way is critical. Insight of all the concerns associated with the energy sector, energy literacy should be a part of education curricula. To approach these challenges constructively, it is crucial to characterize the barriers in terms of energy literacy dimensions in order to adopt effective policy solutions. There is no such work in literature that highlights the perspectives of humans' nature in terms of energy literacy dimensions for constructively tackling the barriers. Thus, in this work, an effort is made for identifying the energy literacy dimensions and investigating the hindering barriers. The unique contribution of this work is:

• Qualitative linkage between SDG-4 and SDG-7 perspectives, as shown in Fig. 1: the mapping of barriers to the RE development in Pakistan using energy literacy dimensions and determining the necessary sub-dimension(s) within cognitive, conative, and affective domains.
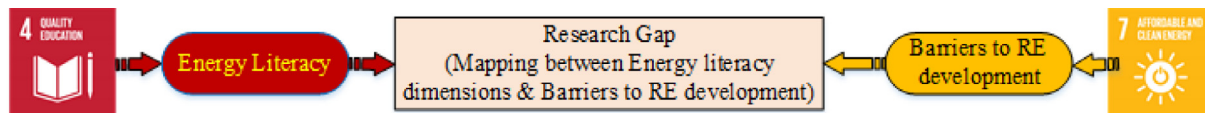

Fig. 1. Main contribution of the work.

2. Methodology

2.1. Three-phases qualitative mapping framework

The current work mainly consists of three phases. In the 1st phase, the barriers to RE development in Pakistan are identified, and classified under a macro-environmental framework (i.e., PESTEL) including political, economic, social, technical, environmental, and legal aspects. In the 2nd phase, dimensions and sub-dimensions of energy literacy are defined from literature in the light of OBE theory [6]. In the 3rd phase, the qualitative mapping of barriers is completed by connecting the barriers with the sub-dimensions of energy literacy. In order to illustrate the proposed methodology, Pakistan has been studied based on the focus group meetings with four officials having expertise in energy and OBE domains. Experts were asked to choose sub-dimensions of energy literacy, in the light of literature-based explanations of dimensions and barriers, through which the corresponding barriers could be addressed constructively. Each of the four experts proposed certain sub-dimension(s) for each of the barriers based on his expertise and experience. The final mapping is done based on the frequency distribution method in which each barrier is mapped with the sub-dimension(s) that is (are) suggested by two or more experts. The information flow for the research design of this work is shown in Fig. 2.
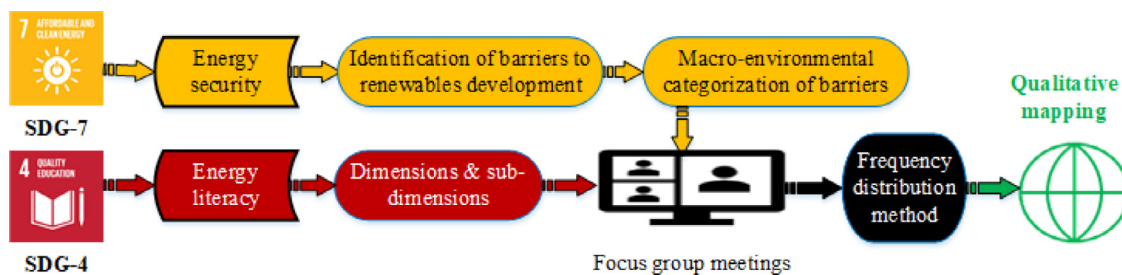
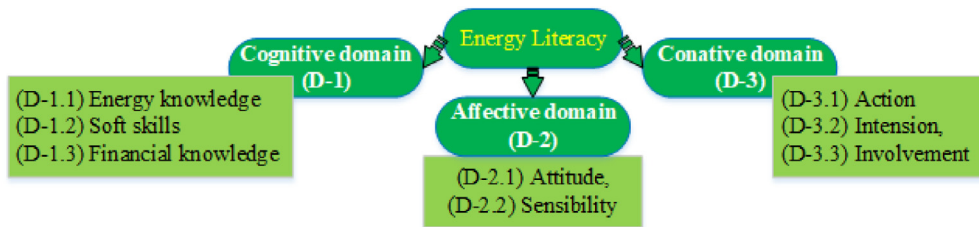**Fig. 2.** Information flow for the research design of current work.

Fig. 3. Energy literacy dimensions and sub-dimensions [8,9].

2.2. Energy literacy dimensions

In the light of OBE theory, energy literacy can be defined in three domains: cognitive, affective, and conative [8,9]. The cognitive domain is about having knowledge of energy subjects and baseline theories [8]. The affective domain is concerned about the residents' attitude towards understanding the energy supply, generation and usage scenarios, and environmental consequences [9]. The third domain of energy literacy, conative, deals with the behavioral perspectives of the individuals [8,9]. It aims to evaluate the awareness of residents about the impact of daily actions associated with generation and consumption of energy, sense of individual's responsibility at the national level as well as at global level, and commitment for adaptation of smart and intelligent consumption ways to save energy for sustainable future. The dimensions and sub-dimensions of energy literacy are portrayed in Fig. 3.

3. Barriers to renewables' development in Pakistan

Pakistan is a developing country immensely blessed with RE resources such as solar, wind, hydro, and biomass. At the same time, an appreciable count of the residents does not have electric power access and this phenomenon is common in the rural areas where majority of people are associated with the agriculture sector. The tendency of migration from rural to urban areas increased rapidly due to the modernization and digitalization of basic facilities provided to the people in the 21st century. Most of the migrants are those who do not have acquired a satisfactory level of basic education. As a result, the number and the intensity of barriers are increasing and are expected to be more and more serious. There are quite a few studies focusing on identifying the barriers to proposing solution strategies. PESTEL has been used to classify all the barriers hindering the RE development in Pakistan, identified through literature review, interviews, and the authors' own deliberation, that are mentioned herein.

There are five barriers in the *political [P]* aspect including [P-1] political instability [4], [P-2] regional conflicts, [P-3] infrastructure deficiencies of institutions [10], [P-4] lack of energy security plan [11], and [P-5] data manipulation and lobbying culture [12]. For the *economic [E]* aspect, three barriers are identified including [E-1] high capital cost [4], [E-2] lack of sufficient market base for attracting investors [13], and [E-3] unrealistic economic feasibility analysis [14]. *Social [S]* aspect is categorized with five barriers that are: [S-1] financial status of households [15], [S-2] lack of ethical and responsibility norms among the residents, [S-3] lack of public awareness [4,15], [S-4] non-accepting response towards green change [15], and [S-5] deprioritized health concerns of the residents [12]. Four barriers are mapped under the flag of *technical [T]* aspect that are: [T-1] lack of research and development (R&D) culture [4], [T-2] unavailability of modern technology in the country [13], [T-3] in-efficient

power transmission and distribution (T&D) infrastructure [4], and [T-4] poor technical skills [16]. *Environmental [EN]* aspect of the macro-environment framework is highlighted with the help of three barriers including [EN-1] uncouth indoor combustion, [EN-2] ecological issues [13], and [EN-3] carelessness for waste disposal [14]. Three barriers are identified related to the *legal [L]* aspect hindering the RE development: [L-1] injustice in implementation of laws, [L-2] ignorance of international treaties [17], and [L-3] flaws in the laws and regulations.

4. Results of qualitative mapping

It is a prerequisite to flourish the energy literacy (an important aspect of SDG-4) sector with proper planning insight of the SDG-7 accomplishment. Without it, it would be difficult to address the barriers hindering the development of renewables for a sustainable future, especially in developing countries such as Pakistan. To highlight the importance of energy literacy for achieving energy security, the barriers influencing the RE development in Pakistan are mapped with the dimensions of energy literacy subjectively. The mapping concluded which of the dimensions, among cognitive, affective, and conative, are important and how much their comparative importance is. Additionally, the contextual nature of the barriers is identified so that each barrier could be addressed through targeted policy implications with the right approach. The qualitative mapping concluded using the frequency distribution method based on the opinions of the experts is portrayed in Fig. 4, in which each barrier is connected to the corresponding energy literacy sub-dimension(s).
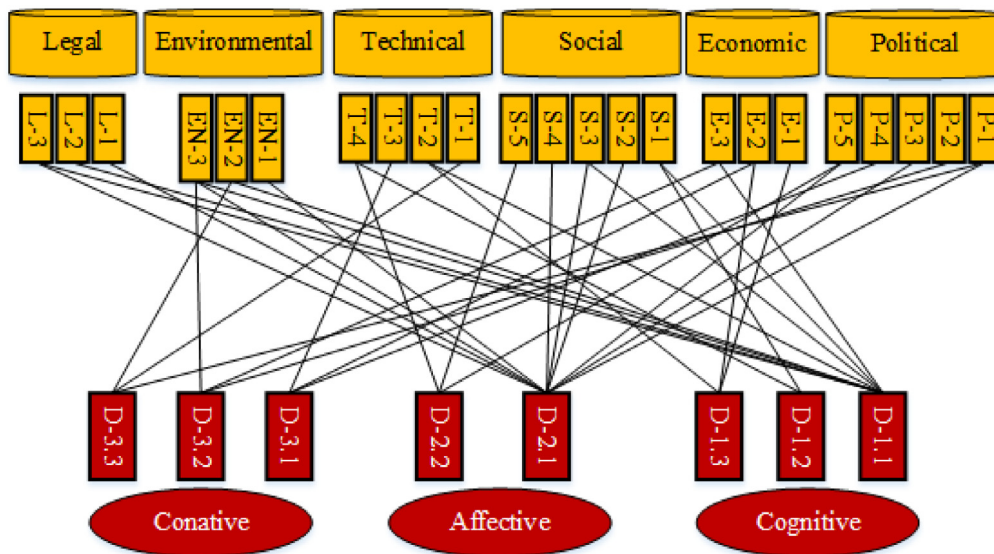

Fig. 4. Qualitative mapping of barriers of RE development with energy literacy dimensions.

The analysis of qualitative mapping (portrayed in Fig. 4) in terms of energy literacy sub-dimensions is depicted in Fig. 5. It elaborates that the affective domain has the maximum number of linkages with barriers, and the cognitive domain has 2nd highest number of linkages. While the conative domain has the minimum number of linkages. Among the sub-dimensions, attitude is the most important perspective of human nature needed to target for addressing 10 out of the 23 barriers. Following the attitude, energy knowledge is the 2nd most important energy literacy sub-dimension. Then, financial knowledge, sensibility, action, intension, and involvement sub-dimensions stand at the same level of importance. While the 'soft skills' is recognized as the least important sub-dimension of energy literacy to address the barriers hindering the RE development in Pakistan.

The analysis of the mapped barriers reveals that many of them require more than one sub-dimensions of energy literacy to get addressed constructively, like political instability (P-1), unrealistic economic feasibility analysis (E-3), lack of public awareness (S-3), unavailability of modern technology (T-2), carelessness for waste disposal (EN-3), and flaws in the laws (L-3), etc. In terms of barriers' categories, technical barriers need the integration of the maximum number of sub-dimensions of energy literacy, followed by political barriers. Economic, social, and
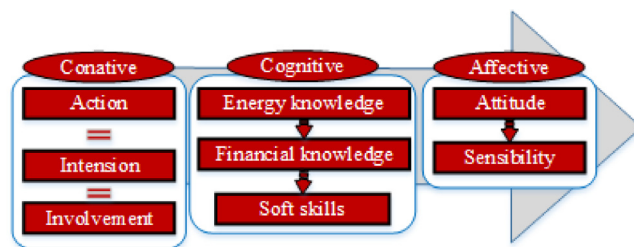
Fig. 5. Importance order of energy literacy dimensions to address the barriers (importance increasing trend from arrow's tail towards head).

environmental barriers need equal numbers of energy literacy sub-dimensions to get integrated after the political barriers, while the legal barriers are mapped with the least number of energy literacy sub-dimensions.

5. Policy implications

From the outcomes of the qualitative mapping based on the frequency distribution method, there are some policy suggestions for Pakistan for overcoming the barriers of RE development:

- Energy literacy should be a part of the education curriculum of every field with the following priority focus of domains: affective > cognitive > conative. This energy literacy education can include the basic knowledge on various energy resources, energy consumption and their impact on environmental sustainability. Along with the technical knowledge, the proportion of curriculum accounts for affective and conative domains of literacy should be heightened and be compulsory as attitude is more important than knowledge sub-dimension. Thus, the awareness of energy savings and environmental protection should be gradually developed through the curriculum among the public to promote the transformation of behavior towards a green lifestyle.
- The political and legal barriers can be effectively removed by energy legislation. Along with the traditional terms on energy legislation, e.g., the feed-in tariff and some other financial and non-financial incentives, a tiered energy price system can be very effective in the formulation of green lifestyles.
- In order to improve public energy literacy, a series of RE projects need to be established in government buildings, public schools, even hospitals and other public institutions, etc., to demonstrate the benefits and convenience of renewables in increasing access to clean energy. This would also increase residents' knowledge on renewables, change their attitudes towards RE projects and even developing green lifestyles.

6. Conclusions

An effort is made to inter-link the barriers of RE development and the energy literacy dimensions in the context of Pakistan. The barriers to RE development in Pakistan are identified and classified in a macro-environmental framework. Focus group meetings are conducted with officials having expertise in energy and OBE domains to highlight the dimensions/ sub-dimensions of energy literacy that could be helpful to address the identified barriers. The main outcomes are:

- 'Affective' is the most important energy literacy dimension mapped with thirteen barriers.
- Technical barriers need the attention of the maximum number of energy literacy sub-dimensions, of six sub-dimensions, among all barriers' categories.
- It is also found that 50% of the barriers require the involvement of more than one sub-dimensions of energy literacy to get addressed constructively.

This new idea of mapping the barriers of RE development (SDG-7 perspective) with the energy literacy dimensions (SDG-4 perspective) can be promoted to other countries, especially in the developing world. So that the contextual nature of barriers could be analyzed in a systematic way, and the most influential perspective of humans' nature in terms of energy literacy dimensions could be identified to get targeted for addressing the barriers hindering sustainable development.

CRediT authorship contribution statement

Aamir Mehmood: Conceptualization, Data curation, Methodology, Formal analysis, Writing – original draft, Writing – review & editing. **Ruojue Lin:** Writing – review & editing. **Long Zhang:** Methodology, Writing – review & editing. **Carman K.M. Lee:** Supervision. **J.Z. Ren:** Conceptualization, Supervision, Writing – review & editing, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

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