

Green Technologies and Innovations for Sustainable Development

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Abstract. The main purpose of this study is to provide valuable information about the challenges and opportunities faced by Uzbekistan in the implementation of green technologies. By paying special attention to sustainable development and innovation, Uzbekistan can pave the way for a green economy. The respondents were selected using the snowball sampling method. A survey was conducted to collect the data. The data collection tool was a questionnaire, which included questions on the Likert scale to study the degree of agreement or disagreement of respondents with this statement. In total, 51 people participated in the study. The survey revealed a number of barriers related to the introduction of green technologies in a number of industries, such as a lack of knowledge and understanding by Uzbek citizens of the benefits of the introduction of green technologies, financial constraints, inadequate regulatory framework, lack of research and development and skilled labor for the introduction of green technologies. However, for the introduction of green technologies, factors such as the abundance of renewable energy sources, the government's firm commitment to achieving sustainable development, encouraging businesses to adopt sustainable practices and the formation of a culture of innovation create favorable opportunities.

Key words: Environmental challenges; Sustainable development; Green technologies.

1 Introduction

Currently, the world is experiencing a number of environmental challenges, such as extreme climate changes, resource depletions and extensive environmental pollution [12]. As a result, this has compelled most nations, including Uzbekistan, to reconsider their methods of growth and has raised the need for adoption of various interdisciplinary green technologies to identify and address various environmental concerns [7]. The term 'green technology' can be broadly defined as an environmental or a clean technology encompassing different innovations aimed at minimizing the environmental impact of human activities [19].

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Sustainability can be achieved through meeting four fundamental principles of green technology policy, these are: 1) the environment – a country’s efforts towards maintaining a protection and minimization of negative effects on the environment; 2) energy – focusing on energy efficiency and reduction of energy usage; 3) economy – using technology to foster economic growth of the country; 4) social – enhancing people’s living standards [7]. Thus, green technologies can be successfully implemented in various sectors of the economy as a part of sustainable development (in agriculture [2, 9, 11, 15, 17]; in transportation [1, 4, 10, 20]; in waste management [5, 6]).

1.1 Problem statement

Uzbekistan is a developing country with a growing economy. Like many other countries, the country is faced with different environmental issues.

One of the key environmental challenges faced by Uzbekistan is air pollution. In the country, about 64% of emission into the atmosphere comes from urban transports [8]. In Tashkent city currently, there are over 460 thousand registered vehicles. About 75% of vehicles in the capital city run on gasoline and diesel engines [14]. Waste management is another environmental challenge in Uzbekistan. Annually, in the country 7 million tons of solid household waste is produced and only 32% of this amount is recycled. Despite efforts made in cutting waste generation in the country by 50% before 2030, observations of parliamentary commission projected a doubling of waste generation by 2030 [16]. Moreover, Uzbekistan is vulnerable to climate changes. Rising temperature in the country is posing another threat to the country’s agriculture, infrastructure and ecosystem. These challenges as a consequence have necessitated the adoption of sustainable practices and the integration of innovative technologies to address environmental concerns and to pursue sustainable development.

However, the integration of green technologies in Uzbekistan is not without its challenges. It requires a paradigm shift in how businesses operate, communities adapt and government legislates.

1.2 Research objectives

The main purpose of the research is to provide valuable insights into the challenges and opportunities faced by Uzbekistan in implementing green technologies. With the focus on sustainable development and innovation, the country can pave the way for green economy.

1.3 Research questions

The following research questions are formulated to find the answer to in the end of the study:

1. What are the key challenges faced by Uzbekistan in implementing green technologies?
2. What are the main opportunities for green technologies implementation in Uzbekistan?
3. What strategies can be used for overcoming challenges and maximizing opportunities?

2 Materials and Methods

2.1 Research approach

To study challenges and opportunities faced by Uzbekistan in implementing green technologies, a quantitative descriptive was adopted. This type of a research method gives more focus on the “what” rather than “why” of the research being studied and is useful when

examining different aspects of the phenomenon [13]. It attempts to collect quantifiable information necessary for statistical analysis.

2.2 Participants and sampling

When selecting participants, a snowball sampling technique was employed to reach out to respondents who are not indifferent to environmental challenges in the country and knowledgeable enough in the selected topic area. After the study is completed, participants with relevant characteristics are asked to suggest other contacts who meet the requirements of the study and who will also be willing to participate. These contacts then suggest other possible volunteers and so on. In the research, there were overall 51 participants.

2.3 Data collection

For collecting a quantitative data, to study the challenges and opportunities in green technologies implementation within the country a survey method was applied. According to Williams [18], in the survey study method, the researcher tends to capture phenomena at the moment. A survey in this study was conducted with the use of questionnaire as a data collection instrument.

2.4 Data analysis

In this study, descriptive statistics are used to characterize the association between variables in a selected sample, which provides a more ordered summary of all quantitative data collected [3]. Compared to graphical display, descriptive statistics allow the researcher to provide a more detailed and accurate explanation of the data. On the other hand, it is also proposed to use a graphic display for visual control of the distribution. Data in this study were described using central trend (specifically mean and mode), standard deviation, frequencies, and percentages.

2.5 Research ethics

The research is a multi-stage process in which ethical considerations can arise at every turn. In light of this, the researcher conducted this study alone, taking full responsibility for ensuring ethical behavior at every turn. Prioritizing the safety, rights, well-being and dignity of each participant was the first step taken by the researcher to achieve this goal. In addition, survey respondents were properly informed of the purpose of the study and its exclusive use for academic purposes, helping to ensure that the investigation is conducted with integrity, integrity and purpose. Anonymity, confidentiality and secrecy of participants were also guaranteed.

3 Results

In survey conducted to study the challenges and opportunities in implementation of green technologies in various sectors of Uzbekistan, the number of participants reached out to 51. Among them 70.5% of respondents were male while 29.4% were female respondents. As it can be seen from the given below Table 1, the majority of respondents were at the age of above 45 at 23.5%. Besides, in the survey, the percentage of respondents who had a Bachelor degree level of education was higher than other groups and estimated 56.8%.

Table 1. Respondents' profile.

Parameter	Sign	Quantity	Structure
Gender	Male	36	70.5%
	Female	15	29.4%
Age	20-25	7	13.7%
	26-35	9	17.6%
	36-45	12	23.5%
	Above 45	23	45.0%
Education	Bachelor	29	56.8%
	Master	18	35.2%
	PhD	4	7.8%

When the respondents' views on challenges in implementation of green technologies in various sectors were studied, the following answers were obtained (Table 2).

In the context of green technologies implementation respondents agree with the view that in agriculture sector financial constraints (mean: 3.79; Std: 1.37) and lack of research and development (mean: 3.57; Std: 0.94) being conducted are one of the main challenges. However, they also agreed with the fact that people's lack of awareness on available green technologies and lack of supportive legal environment also cause a challenge for green technologies adoption in the country.

When energy sector was studied for factors creating a barrier for green technologies implementation, respondents "strongly agreed" with the following challenges such as awareness of the latest green technologies (mean: 3.50; Std: 0.94), inadequate regulatory frameworks supporting implementation of green technologies (mean: 3.50; Std: 1.22) and lack of skilled workforce (mean: 3.77; Std: 0.42).

In transportation sector, there were found two main challenges, they are lack of education and awareness campaigns used to inform and engage the public (mean: 3.90; Std: 0.30) and financial constraints (mean: 3.77; Std: 0.42).

Furthermore, in waste management, the main obstacles for implementation of green technologies according to respondents is also lack of education and awareness (mean: 4.00; Std: 0.00), lack of investments (mean: 4.00; Std: 0.00) and lack of R&D (mean: 3.90; Std: 0.30). In addition to above sectors, the views of respondents were also studied in regards to economy sector. According to respondents, the main challenge for green technology implementation in this sector is related with financial constraints (mean: 4.00; Std: 0.00); however, they also agreed that the factors such as lack of education of people, inadequate regulations and lack of capacity also pose a challenge for green technologies implementation.

Table 2. Challenges in implementing green technology in specific sectors.

Challenges in implementing green technology in specific sectors				
	Mean	Mode	Std	Level of opinions
<i>Agriculture</i>				
We have limited awareness and understanding about available green technologies	2.79	3.00	0.50	Agree
Lack of supportive legal environment encouraging investment in green technologies adoption	2.79	3.00	0.52	Agree
Financial constraints	3.79	4.00	1.37	Strongly agree
Lack of research and development	3.57	4.00	0.94	Strongly agree
<i>Energy</i>				
We are not fully aware the latest green technologies	3.50	4.00	0.94	Strongly agree

Challenges in implementing green technology in specific sectors				
	Mean	Mode	Std	Level of opinions
Inadequate regulatory frameworks post an obstacle to the implementation of green technologies	3.50	4.00	1.22	Strongly agree
Green technologies require substantial upfront investment	3.31	4.00	1.03	Strongly agree
Lack of research and development	2.79	3.00	0.52	Agree
Lack of skilled workforce in green technologies implementation	3.77	4.00	0.42	Strongly agree
<i>Transportation</i>				
Many individuals may not fully aware of potential benefits of green vehicles	2.51	3.00	0.50	Agree
To create a legal environment is necessary to increase investment in green technology	3.90	4.00	0.30	Strongly agree
There are lots of financial constraints	3.77	4.00	0.42	Strongly agree
Lack of research and development	2.55	3.00	0.48	Agree
Lack of skilled workforce in green technologies implementation	2.58	3.00	0.52	Agree
<i>Waste management</i>				
Lack of education and awareness campaigns to inform and engage the public	4.00	4.00	0.00	Strongly agree
Inadequate regulatory frameworks pose a challenge	2.52	3.00	0.58	Agree
Upfront investment role is necessary	4.00	4.00	0.00	Strongly agree
Lack of research and development	3.90	4.00	0.30	Strongly agree
<i>Economy</i>				
Lack of education and awareness on the positive impact of green technologies on the environment and economy	2.59	3.00	0.51	Agree
Clear and comprehensive regulations are necessary	2.79	3.00	0.50	Agree
Financial constraints present a significant challenge	4.00	4.00	0.00	Strongly agree
The need for capacity buildings and skills development since green technologies require a skilled workforce	2.55	3.00	0.48	Agree

Strongly disagree: 1.00 - 1.74; / Strongly disagree: 1.75 - 2.49 / Agree: 2.50 – 3.24

Strongly agree: 3.25 – 4.00

Apart from the respondents' view on challenges, in the survey a focus of the study was also given on finding the key opportunities for green technology implementation. According to respondents in Uzbekistan, there are many renewable energy projects and this creates a good opportunity for green technologies implementation (mean: 3.55; Std: 0.49). In addition to this, the government's commitment towards achieving sustainable development also creates an opportunity for green technologies adoption in the country (mean: 3.12; Std: 0.33). Besides, respondents strongly agreed with the view that incentivizing business to adopt sustainable practices (mean: 3.76; Std: 0.42), providing support for green technology start-ups (mean: 4.00; Std: 0.00) and fostering a culture of innovation in the country (mean: 3.90; Std: 0.30) also creates an opportunity for green technologies implementation in various sectors. In addition to this, collaboration between governments also was found to be important in green technologies adoption in Uzbekistan (mean: 4.00; Std: 0.00).

Table 3. Opportunities for green technology implementation.

Opportunities for green technology implementation	Mean	Mode	Std	Level of opinions
The abundance of renewable energy resources in Uzbekistan	3.55	4.00	0.49	Strongly agree
The government's strong commitment towards achieving sustainable development	3.12	4.00	0.33	Strongly agree
Incentivizing business to adopt sustainable practices	3.76	4.00	0.42	Strongly agree
Providing support for green technology start-ups	4.00	4.00	0.00	Strongly agree
Fostering a culture of innovation	3.90	4.00	0.30	Strongly agree
Collaboration between the governments	4.00	4.00	0.00	Strongly agree

Strongly disagree: 1.00 - 1.74; / Strongly disagree: 1.75 - 2.49 / Agree: 2.50 - 3.24

Strongly agree: 3.25 - 4.00

4 Discussion

The survey revealed a number of barriers associated with the introduction of green technologies in several industries, after analysing the situation in Uzbekistan in the context of issues related to their implementation. If these issues are not adequately addressed, they can hinder the promotion of sustainability and innovation.

One of the main issues among Uzbek citizens in implementation of green technologies is related with the lack of knowledge and awareness. Due to lack of their understanding about perceived benefits of green technologies in addressing different environmental issues it may be difficult for people to accept and support the adoption of such new and green technologies in the country. Another issue is associated with weak and inadequate regulatory frameworks supporting the adoption of green technologies in Uzbekistan. To encourage such technologies acceptance within the country, adequate legal frameworks need to be encouraged by the government. In addition to this, different sectors in Uzbekistan are challenged by financial constrains in green technologies adoption process. This is because implementation of such technologies is expensive and SMEs (small, medium-sized enterprises) may find it difficult to adopt. To overcome such financial obstacles the government should invest and provide some financial support in the form of grants, subsidies, loans and others for entrepreneurs. Furthermore, among these challenges, Uzbekistan has very few research and development centres. Due to this, the country's efforts made towards adoption of green technologies are hindered. Moreover, a lack of capacity building and skills create also a challenge in adoption of green technologies. This is because a successful implementation of such green technologies requires the workforce to be equipped with necessary technical knowledge and skills. Besides, it was found that current infrastructure is old in the country. This may also create a challenge for adoption of green technologies.

In Uzbekistan, the renewable energy sources such as wind, solar and geothermal are considered to be abundant. This creates a good opportunity for green technologies adoption and builds a sustainable source of energy for the country. Moreover, by achieving a reduced dependence on fossil fuel, like many other sustainable countries, Uzbekistan could also make its own positive contribution to the world's transition to a low-carbon economy. The country could also achieve this through its investments in renewable energy technologies like solar and wind panels. As seen from the study, another opportunity for the country comes from educating young generating and workforce for required skills and knowledge. To foster entrepreneurship and innovation in green technologies industry the country's made investments into technical education and training of workforce can be a good start for this.

In addition to above mentioned potentials of the country, the role of economic diversification is also important in fostering cross-sectoral integration of green technologies throughout the country. Moreover, among other created opportunities for fostering green technologies adoption, the country can think of partnership and knowledge sharing to bridge the gap between research and real implementation.

5 Conclusion

Like in many other developing countries, in Uzbekistan there are many environment-related issues that raise a need for immediate solutions to be taken. However, for implementation of new green technologies first of all it is critical to have a better understanding about those issues. From the study it was found that among one of the main issues that need to be tackled in Uzbekistan is related with air pollution. Due to poor quality of air caused by increased car emission in the country, burning fossil fuels and recent industrial activities not only it has a negative impact on human well-being but also negatively impact the environment and climate. Another problem that urges green technologies implementation is water pollution. In Uzbekistan due to inadequate disposal of agricultural and industrial waste there is a threat on clean drinking water system of the country. If not solved on time the negative impact of water pollution may harm the country's ecosystem and biodiversity. In addition to this, inadequate waste management in Uzbekistan creates another issue causing waste accumulation in landfills. It has a harmful effect not only on public health but also on the environment as well. In addition to above mentioned issues Uzbekistan is not an exemption from global warming related issues. The country is seriously challenged these days by changing rainfall patterns and rising temperatures. If a set of adequate actions are not taken towards raising temperature, it may pose a serious threat to national infrastructure, ecosystem and agriculture of the country. This is where the role and adoption of various green technologies and sustainable behaviour throughout the country is important.

The introduction of green technologies can significantly mitigate these problems and increase environmental sustainability in Uzbekistan. A country can significantly reduce its environmental impact and support international efforts to prevent climate change by adopting sustainable agricultural practices, introducing renewable energy sources and upgrading waste management systems.

6 Limitations

This research is not without limitations. Due to lack of time provided, only 51 respondents' views were taken into consideration. In the future the number of respondents should be increased. The higher the number of research participants, the higher the rate of data reliability and a chance for a generalization.

6.1 Practical implications

The present study findings can be used for development of sustainable development in Uzbekistan. The study contains a very useful data in regards to challenges related with green technologies in different sectors. A comprehend perspective can provide interested people with deeper insight into challenges faced by different sectors and what opportunities has Uzbekistan for green technology implementation. The present research also can be useful for future research who attempts to study the topic of "green technologies implementation in Uzbekistan". Since the present study contains itself all necessary information for their research starting with environmental challenges that make the role of green technologies

implementation important, challenges and opportunities associated with green technologies implementation in the country.

6.2 Recommendations

It is crucial to develop practical plans to address these challenges in order to overcome obstacles and optimize the potential for introducing green technologies in Uzbekistan. Uzbekistan can overcome challenges and fully realize the potential of green technologies for sustainable development and innovation by implementing the following measures.

To begin with, it is critical for the government to improve the awareness and knowledge of its people about the rising environmental issues and importance of adoption green technologies. To achieve this, some rigorous education work needs to be conducted such as launching campaigns improving the understanding of people about the benefits of green technologies and importance of sustainability in addressing the issues. Such campaigns can be performed among the local communities and schools. Another strategy is to encourage adequate frameworks supporting green technologies adoption. Clear legislations may as a result motivate some SMEs operating in different sectors to make their own contribution, to invest and make a transition towards sustainable and responsible practices.

In addition to above SMEs adoption of green technologies should be supported by the government. Since adoption of green technologies is expensive procedure, to reduce the financial burden the government could offer various financial solutions in the form of subsidies, grants and some funding. To achieve this, the government could collaborate with various financial institutions, business sector stakeholders and others. Besides, to foster the adoption of green technologies in the country, the government in Uzbekistan should encourage research and development of different green technologies. To that end, the government should establish research centres and academic institutions and provide financial support for projects promoting green technologies creation in the country.

Moreover, to promote green technologies adoption in the country, the role of public and private partnership is also important. Such partnerships could maximize the government's initiative related with green technologies implementation to address various environmental issues through knowledge sharing between entrepreneurs and government agencies. Another successful strategy that could encourage green technologies adoption in the country is integration planning. With such planning in hand, the government can determine easily which region in the country needs to be modernized and lacks in financial support to bring green technologies into certain industry and make a transition to environmentally friendly operations.

Furthermore, adopting green technologies in a country implies cross-governmental cooperation; working together with foreign organizations and taking part in international projects to maximize the use of funds, expertise and best practices in the field of green technologies; building alliances with countries that have effectively implemented green technologies so one can benefit from their knowledge and change appropriate tactics to suit regional needs. Uzbekistan can overcome obstacles and take full advantage of opportunities for the introduction of green technologies, applying these tactics in practice. This will improve the country's economy, protect the environment and improve the well-being of its people, and promote sustainability and creativity.

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