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SOCIOECONOMIC DETERMINANTS INFLUENCING THE ADOPTION OF RENEWABLE ENERGY TECHNOLOGIES AMONG SMALL AND MEDIUM ENTERPRISES: A FIELD STUDY FROM FAISALABAD, PAKISTAN

Haider Ali[*1], Rahm Dil[2], Muhammad Hanif[3], Syed Mehtab Ali Shah[4], Talha Farid Ansari[5]

[*1]*Department of Economics, Gomal University Dera Ismail Khan, Pakistan*
[2]*Department of Economics, Islamia College Peshawar, Pakistan*
[3]*Department of Agricultural Economics faculty of Agricultural Social Sciences Sindh Agriculture university Tandojam*
[4]*Department of Agricultural Economics, Faculty of Agricultural Social Sciences Sindh Agriculture University Tandojam Pakistan*
[5]*Department of political science, Faculty of Social Sciences Bahaudin Zakariya University Multan, Pakistan*

[*1]haiderali555677@gmail.com, [2]rahmdilsherani786@gmail.com, [3]mhanifthebo@gmail.com, [4]syedmehtabalishahj@gmail.com, [5]talhaansari2k@gmail.com

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Corresponding Author: *
Haider Ali

Abstract

The renewable energy technologies (RETs) uptake on small and medium enterprises (SMEs) moves along with the expanding climate and energy crisis of the developing world, globalization, and the environment. The primary determinants of socioeconomics along with climate change responses in Pakistan remains the adoption of retrial technology in the small and medium enterprises in developing Pakistan. This primary study seeks socioeconomics and climate change adoption technologies in the city of Faisalabad, Pakistan through surveyed structured and open questionnaires and field notes, questionnaires, and unstructured and open interviews. This city of Faisalabad returned a district of 205 small and medium enterprises in the industries of furniture and fixture manufacturing, retailing, services, and food processing. The study returned district 205 samples. Several primary quantitative district study and qualitative study of responses closure determined levels of adoption and cluster of responses in motivation and barrier. The study district provided a lens of social capital the study. The study district also provided the major barrier of capital and technical support in adoption. Overall, this study recommends a lens study. This study of Faisalabad and Pakistan recommends the lens of social capital in the adoption of deteriorated technology.

INTRODUCTION

Chapter#1

For small and medium enterprises (SMEs), the use renewable energy technologies (RETs) is necessary for economic growth and the saving of our planet. This is especially important for developing economies like Pakistan, where energy needs grow rapidly because of industrial growth and the non-renewable energy alternatives become wildly expensive.SMEs are fundamental to the Pakistani economy in term of employment and GDP. That's why it's important to study the energy choices made by these enterprises. This study analyzes these choices within the context of socioeconomic factors in the case of Faisalabad, which represents the semi urban and rural regions of Pakistan. Here, the energy conditions are poor and the renewable energy alternatives are expensive. Pakistan's energy sustainability problem is complicated by the shortages of energy, the constantly increasing fossil fuel dependence and the negative environmental effects [1]. For SMEs, the negative effects are worsened by their financial constraints, low levels of technical expertise, poorly designed policies and the several socioeconomic factors which lower their willingness to use RETs [2]. These factors can only be analyzed through the socioeconomic adoption model, because adoption is a multi-faceted problem and for any economical decision there are always opportunity costs.Social norms, awareness levels, education, and access to information networks also help shape them [3]. Financial constraints become critical barriers to the adoption of RET among SMEs in Pakistan. The high upfront costs of installing renewable energy systems, including solar panels and biogas units, are likely to discourage many solar SMEs, which operate on thin profit margins, from making such investments [4]. Even though the long-term benefits of renewable energy investments are cost savings and price stability when compared with fossil fuels, the costs involved in the initial investment are very likely to discourage many prospective adopters. Although microfinance schemes and government subsidies are trying to solve these issues, their impact and coverage are still limited and need further improvement and targeted outreach [5]. The adoption of renewable energy systems can also be explained by awareness and knowledge of the renewable technologies available. SME owners in Faisalabad are unaware of the existence, operation, and advantages of renewable energy technologies [6]. Weak extension services and institutional support are often the reason for these knowledge gaps. Likewise, awareness and training activities institutionalized in other regions that are similar to this one [1][7]. Social influence and acceptance within the community are also important for attitudes toward renewable energy, where early adopters. in particular, can help influence these attitudes.The policy and regulatory environment is one of the three external influences on SME choices. Lack of discrete energy policies, administrative obstruction and lack of financial motivation for the use of REIs contribute to SMEs losing confidence on investment in RET Systems [8]. An increasingly consistent policy, simplified processes and clear policies would create not only a conducive atmosphere but also lure more SMEs to consider an investment in clean energy. The participation and enabling conditions provided by local governments and energy departments for access to technical support and finance become critical factors in enhancing the adoption rates.

The availability of infrastructure, including access to the grid and maintenance services, also constrains the potential for renewable energy adoption. Intermittent grid electricity in most areas of Faisalabad, and this also leads to the enterprises (SMEs) search for alternative sources.SME less likely to use a technology when there are no local service providers can decrease likelihood that SME will adopt.Finally, the adoption decision is also mediated by socioeconomic status (education, income,

business size). SMEs with higher education level of management are more likely to engage in new practices including renewable energy adoption [9]. In addition, bigger SMEs which have a higher level of resources are more able to invest and bear the costs associated with new technology adoption.To the end, the decision-making process of SMEs in Faisalabad with respect to accepting renewable energy technologies is shaped by a combination of financial, informational, policy infrastructural and social factors. These socioeconomic determinants, if addressed with comprehensive policy integration, financial incentives (Elaine), and awareness programs supported with infrastructure provision at the household levels could increase acceptance of renewable energy. These could not only lower the cost of energy for SMEs, but would also contribute towards Pakistan's wider objectives for energy security, environmental sustainability and economic robustness.

Chapter#2.Methodology:

2.1 Research Design

This research study employs a primary data based research design to investigate the socioeconomic factors that influence adoption of renewable energy technologies in SMEs in Faisalabad, Pakistan. A cross-sectional format was used (iii), the data were collected from individuals at one point in time. The research depends on quantitative and qualitative information of primary source to achieve towards the two measurable with adopting context insights considering influencer over Small MEDs for REs.

Structured questionnaire captured quantifiable information about demographic and business characteristics, awareness and adoption behaviour, while semi structured interviews provided deeper insights into the motivations, challenge and institutional support influencing adoption decisions.

Additionally field observations were conducted to verify on ground adoption of renewable technologies ensuring data credibility and triangulation.

2.2 Study Area

The research focused on Faisalabad, a key industrial city in Punjab, Pakistan, known for its many small and medium enterprises (SMEs) in textiles, manufacturing, and services. The city faces energy issues like unreliable supply and high costs, making solar energy a potential solution, though there are obstacles to its adoption.

2.3 Target Population

The target population included owners and managers of small and medium enterprises in Faisalabad. It covered sectors like manufacturing, retail, services, and food processing, which are affected by energy costs.

2.4 Sample Size and Sampling Technique

A stratified random sampling technique was used to represent different sectors among SMEs. The sampling frame was created from records of the Faisalabad Chamber of Commerce and SMEDA. Using Cochran's formula, the minimum sample size was set at 196 with a 95% confidence level. To manage non-responses, 220 SMEs were contacted, yielding 205 valid responses for a 93% response rate.

2.5 Data Collection Methods

Primary data were collected through three complementary instruments:

Structured questionnaire,semi structured interviews, and field observation.These methods were designed to capture both measurable socioeconomic factors and qualitative contextual insights.

2.5.1 Structured Questionnaire

The structured questionnaire was created to study energy usage among SMEs. It includes five sections:

- 1. Demographics: Information about SME onwer/managers like age,gender, education and experience.
- 2. Business Profile: Details on the type of business, no of employees, capital investment and monthly earnings.
- 3. Energy Usage: urrent energy, sources, electricity costs and supply reliability.

- 4. Awareness and Attitude : understandings and beliefs about renewable energy technologies.
- 5. Adoption Behaviour: Status of adopting renewable energy, reasons for or against adoption and barriers faced.

Response were rated on a five point scale. The questionnaire was pre tested with 20 SMEs to ensure clarity and validity. Data collection involved face to face interviews in Urdu and Punjabi for better understanding.

2.5.2 Semi-Structured Interviews

Fifteen semi-structured interviews with SME owners, energy providers, and local authorities explored motivations, barriers, institutional support, financial challenges, and social influences for adopting renewable energy. Each interview lasted 30–45 minutes and was transcribed for analysis.

2.5.3 Field Observations

Field observations were conducted at chosen SMEs to confirm the physical existence and operation of renewable energy systems, mainly solar panels. The observations encompassed:

- Quality of installation and maintenance practices
- Patterns of energy usage
- Practical difficulties in system operation

These observations were instrumental in validating survey responses and offered further context regarding the implementation of renewable energy in SMEs located in Faisalabad.

2.6 Data Analysis Techniques

Collected primary data were analyzed using both quantitative and qualitative method.

2.6.1 Quantitative Analysis

We put the survey answers into a program called SPSS (Version 26). Then, we did a few things:

- We used basic stats to describe the small business stuff: energy use and how much they knew.
- We checked if things correlated socioeconomic stuff (education, income, company size, awareness) was tied to using renewable energy tech.
- We used a regression thingy to figure out what factors really predicted if a small business would use renewable energy.

2.6.2 Qualitative Analysis

We looked at the interview transcripts by using thematic analysis, and we saw some themes keep popping up. These included things like:

- Money problems and getting loans
- Not knowing enough about the tech or how to do things
- Problems with rules and how things are governed
- What the community thinks and whether they're okay with it

This analysis gave more background to the numbers and helped us get a better idea of why people were adopting the technology.

2.7 Validity and Reliability

Validity and reliability were guaranteed through:

Expert evaluation of the questionnaire to assess content and construct validity

Pilot testing conducted with 20 subject matter experts to enhance the questions

Cronbach's Alpha values surpassing 0.80 to ensure internal consistency

Triangulation of surveys, interviews, and observations to validate findings

2.9 Limitations

This study gives us some solid info, but it's got a few limits:

- It only looks at businesses in Faisalabad, so the results might not apply to all small and medium businesses in Pakistan.
- The data is from one point in time, so we can see connections, but not prove cause and effect.
- There could be some bias from who didn't respond, though we got a pretty good response rate (93%), which helps.

Even with these limits, the way we did the study gives us a base to look at what drives

renewable energy use in Faisalabad's small and medium-sized businesses.

Chapter#3. Results

3.1 Descriptive Statistics

This study got 205 usable responses from SME owners/managers in Faisalabad. Most of those who answered were men (82%), aged 25–50 years. About 60% had at least a bachelor's degree, which means they have a decent education. Most of the SMEs were small businesses (1–50 employees, 70%), with the rest being medium-sized (51–150 employees, 30%).

On the topic of energy, over 75% of the SMEs said they often have power outages. They also noted that monthly electricity bills take up 10%_ 20% of their operation costs. Around 40% of SMEs had already started using some kind of renewable energy like solar panels. The rest were either thinking about it 25% or were not planning to at all 35%.

3.2 Awareness and Knowledge of Renewable Energy

The levels of awareness exhibited considerable variation. Small and medium-sized enterprises (SMEs) that possessed higher educational qualifications and had greater access to information networks showed a more profound understanding of renewable energy technologies. Participants pointed out that insufficient technical knowledge (45%) and a lack of information regarding government subsidies (38%) were significant obstacles. This observation is consistent with previous research that underscores the importance of knowledge and awareness in influencing decisions related to the adoption of renewable energy [6][7].

3.3 Socioeconomic Determinants

So, we did some digging, and here's what seems to push small and medium-sized businesses toward using renewable energy tech:

- **Smarter Owners:** Owners or managers with more schooling are more keen to use it.
- **More Money:**If the business makes more each month, they're also more likely to put money into renewable energy.
- **Bigger Business:** Medium-sized businesses pick it up more often than smaller ones.
- **Knowing More:** People who've been to training or had tech help are way more likely to go for it too.

The big problem? Money. If these businesses are short on cash, they just can't pay for the upfront costs, even if they know it'll save them later. Stuff like policy help and discounts could get them going, but there's just not enough of that around.

3.4 Field Observations and Interviews

Based on field visits, solar PV systems seem to be the most common renewable tech people use. We saw that medium-sized businesses put money into hybrid systems that mix solar and grid power. This helps keep things running when the power goes out.Correlation and regression analyses revealed the following significant determinats of RET adoption:

Education of SME onwers/ Managers_positively correlated ($r=0.42, p<0.01$); higher education increases likelihood of adoption.

Monthly income SMEs with higher revenue were more likely to invest in renewable energy ($r=0.39, p<0.01$).

Firm size_ medium _scale SMEs had greater adoption rates compared to small scale units ($r=0.31, p<0.05$).

Awareness and Training respondents who participated in training programs or had access to technical support were significantly more likely to adopt RETs .

Financial constraints emerged as a critical barrier as SMEs with lower liquidity reported inability to afford upfront investment despite recognizing long term benefits.

Policy incentives and subsidies were cited as motivating factors though limited availability reduced overall impact.

From interviews, it's clear that what others do affects whether people choose to adopt. If their friends or business contacts are

doing it, they're more likely to try renewable energy. Those who try it first can really get others interested.

Some problems that came up in interviews were:

- It's hard to find tech support and maintenance.
- The initial costs are high, even if it saves money later.
- Getting subsidies involves a lot of red tape.

Basically, this info lines up with the numbers. It shows that money, knowledge, advertising, and what others think really affects who decides to adopt.

Chapter#4. Discussion

This research shows that things like money and education have a big impact on whether small and medium-sized businesses (SMEs) in Faisalabad use renewable energy. We looked at info from surveys, interviews, and on-site visits, and it turns out that it's not just about having the money. Things like how educated the managers are, how much they know about renewable energy, the size of the business, what other people think, and whether the government is helpful all play a part. The numbers show a clear link between these things and whether a business will use renewable energy. The interviews help us understand why some businesses owners and managers are for it,what holds them back and how they make their decision. It turns out that education and awareness are key. SMEs with better educated manager understands the good things about renewable energy like lower energy bills reliable operations and being better for the environment.. These managers are better at understanding the technical details, figuring out if it's a good investment in the long run, and dealing with the steps needed to install the technology and get subsidies. Also, knowing about renewable energy is closely tied to having access to information, training, and knowing people in the industry. The interviews showed that managers who went to workshops or talked to businesses already using renewable energy were more likely to give it a try. This matches what other studies have found in other cities in Pakistan, like Lahore and Islamabad, where manager knowledge and awareness were good signs that a business would use renewable energy [1][2].The results show that targeted campaigns to raise understanding, programs to build skills, and efforts to educate are key to getting more people to accept new things, most of all small businesses that do not know much about technical information.

Company size and income were also big factors in acceptance. Medium-sized small to medium businesses (SMEs), which usually have higher incomes and better organization, were more likely to invest in renewable energy technologies (RETs) than smaller ones. On-site visits confirmed that medium-sized businesses could set aside money for installing and upkeep solar panels, while smaller businesses had money problems. High initial costs were often mentioned as a big problem during talks, which shows the problem that SMEs with small earnings face. The results suggest that although money helps investment, it also affects other things, like what managers know and who they listen to, when deciding to accept. The study's results go along with proof from other countries, where company size and money always say whether renewable energy is accepted. This shows that SMEs with enough money are in a better spot to handle investment risks and enjoy long-term savings.

Social groups and seeing how things work also made acceptance stronger in Faisalabad. SMEs usually got information from nearby businesses or others in their field before deciding to invest in renewable things. Early users in business groups were examples, showing real cases of saving money, having better energy reliability, and being technically doable. This influence from others made a learning place, where seeing good work pushed others in the SME group to accept more widely. Talks showed that managers often talked about renewable energy in regular business groups, sharing thoughts about install problems, upkeep ways, and money choices. These

results match past research that stresses how important others are in accepting technology, where early users are leaders, and sharing knowledge in groups can really change choices.[5][6].Money problems continue to trouble many small and medium-sized businesses in Faisalabad. While medium-sized firms could pay for renewable energy systems, smaller businesses had big initial costs, even when they knew about the long-term gains. The research showed that even though there are government help and small loan programs, many small and medium-sized businesses do not know about them or find the paperwork too hard. This issue shows that we need easy financial support, like simple subsidy applications, low-interest loans aimed at the right people, and payment options that work for them. By cutting money worries, leaders can help smaller businesses get past early cost problems, which would spread the use of renewable energy tech to different business sizes and areas.

Assistance from policymakers and institutions was named another important thing that affects use. Small and medium-sized businesses said they had trouble understanding energy rules, getting permits, and finding tech help. Programs are not as useful when policies are not put in place the same way each time and when it is not clear who can get the rewards. Interview info showed that small and medium-sized businesses that had better access to government programs, tech training, and after-sales help felt more sure about using renewable energy systems. These results show that organized policy plans, institutional support, and tech help are key, as they can shape a good space for small and medium-sized businesses to put money into renewable energy. Other studies from growing countries have come to similar ends, where policy clarity, aid, and service extensions greatly affect decisions to adopt[7][8].

It was also super important to think about tech skills and keeping things running. Small businesses often worried if green energy stuff, like solar panels, would last, mostly 'cause they weren't sure they could get help fixing them when things broke. We noticed that medium-sized businesses usually had deals with local repair shops to keep their systems up and running smoothly. But the smaller guys usually couldn't find tech people, which made them shy away from green energy, even if they knew it could help. This shows why training courses and local repair services are key for getting businesses to switch and keeping their systems working well.

From looking at stuff like education, money, business size, info, what others think, rules, and tech know-how, it's clear that going green is a tricky thing. It's not just one thing that makes a business switch it's when a bench of good things line up.knowing this is super important for planning how to help businesses in Faisalabad . Like just telling them about green energy might not be enough if they can't afford it. And giving them money might not work if they don't know how to use the tech or can't fixed it. this is super important for p. So, we need plans that mix money help, training, good rules, and showing them how it's done by other businesses to get them to use green energy.

What we learned can help the people who make rules, those in the energy biz, and other important people. Rule-makers should think about giving money to the little guys, making sure they can easily get loans and other financial help. Business groups can really help by holding workshops, showing off cool projects, and letting businesses learn from each other to calm their worries. Tech folks should try to reach out to small businesses, offering to set up, fix, and help with their systems after they're sold, which will make businesses trust green energy more. By sorting out these things that are all mixed together, these folks can not only get more businesses to switch but also help them save energy, stay strong, and help the environment in Faisalabad.

Chapter#5. Conclusion

This study checked out what gets small and medium-sized businesses (SMEs) in Faisalabad, Pakistan, to use renewable energy tech (RETs). We only used info we got ourselves through surveys, interviews, and checking out sites.

We wanted to figure out what helps or stops these businesses from investing in things like solar panels. Faisalabad is a big industrial spot, so they are always dealing with power shortages and pricey electricity which makes things tough for SMEs. By getting our own data we saw the numbers and got a feel for how bosses make decisions how much money they have and what's going on in their communities.

Turns out it's not just one thing that makes SMEs go green; it's a mix of money stuff, education, the way their business is set up, what people around them think, and if they have the right stuff in place.

Education and knowing what's up are super critical. SMEs run by folks with degrees or energy management training were way more likely to use renewable energy. They get the good that comes from renewable energy and can handle the tech stuff and paperwork. Also, when SMEs saw renewable tech in action or heard about special programs, they were more likely to try it out.

Money's a big deal, too. Small SMEs that don't make much dough struggle with the upfront expenses of stuff like solar panels. They know it'll save them money later on because they won't have as high of electricity bills, but they can't drop the cash right now. Medium-sized SMEs with more cash were better able to make the investment. Giving SMEs the money can help since they can use government money through things like financial relief, making it doable for smaller companies to go green.

How big a company is and how it's set up also matters. Medium-sized SMEs were more likely to use RES since compared to smaller ones. They usually have better management, tech support, and money, so they can handle setting up and keeping RETs going. We saw medium-sized companies using setups that combine solar energy with regular electricity. Small SMEs often just stick with what they know due to money and skill issues. So, policies and help should be based on how big a company is.

The study shows that what others think really shapes if a business goes green. We heard from owners that they pick up ideas from nearby businesses or those in the same industry. If someone tries solar panels, and it works out well cutting electricity costs and being reliable, others are more likely to give it a shot too. This word-of-mouth thing really makes a difference, especially where there isn't much official help available. So, plans that use these groups, like demos and workshops, could be a good way to get more people on board.

Getting the right rules and support from the government matters a lot. Some owners said they got slowed down by red tape, confusing instructions, and not being sure if they could get money back from the government. Even when there are offers, it can be too hard to apply or not enough info is given. Easy paperwork, clear rules, and getting the word out can help owners make smart choices. Having help with installing, fixing, and keeping things running is also key. People don't want to invest if they can't find someone to fix things if they break or are worried about extra expenses. Making rules easier and having good support can really help more businesses use green tech.

Our results say that using renewable energy is tied to money, company structure, education, what people think, and how the government acts. Money helps to invest in energy. Learning about energy makes the business owner more confident of his option. His social environment help validate his decision

Our study implies that renewable power is intertwined with many factors such as funds, organisation, knowledge, surrounding environment. In order to promote Faisalabad SMEs should incorporate fund raising, awareness

programs. Doing this would reduce the demand and supply from the business.

This study goes beyond Faisalabad. It offers guidance in making policies at the provincial and national level. By learning how socioeconomic issues change renewable energy, those in charge can make specific policies to help SME's get more for their money. Also, targets for helping small business owners can enhance the rate.

In conclusion, helping Faisalabad SMEs implement RE requires many different approaches. Cash support, skill improvement, knowledge programs, social surroundings and rules must all work together in order to resolve the problem. This test used data from research and field tests so the conclusion can be reached.

Future studies can see the time pattern to target the rate and make polices.

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