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RESEARCH ARTICLE

Sustain Renewable Energy – Lessons for Bangladesh from an Interprofessional Study Conducted in West Michigan, USA

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Abstract

Objective: Between 1999–2018, the Global Climate Risk Index placed Bangladesh in the top 10 countries most affected from extreme weather events associated with climate change. Implementation of alternative energy may minimize climate change in vulnerable countries. Our objectives were to characterize public knowledge and perceptions of costs and benefits of renewable energy in west Michigan, USA, and recommend areas in which policy discussions on renewable energy should focus. **Method:** Via email and postal service, we distributed a survey to 1,000 randomly-selected university employees, and 1,000 residents of primarily Ottawa and Kent counties in west Michigan (Grand Valley State University Institutional Review Board #20-118-H). **Result:** A total of 313 respondents completed the survey, including 170 university employees and 122 county residents. Results suggest that 12.5% of people older than age 60, and people with no college degree use alternative energy sources more than other age classes or those with higher education. Females ($p = 0.0636$) and people who have lived in their homes for 10–15 years ($p = 0.0802$) perceived renewable energy as less costly than other sources. Although females perceived less knowledge than males ($p = 0.0001$), there were no differences in perceived knowledge level among respondents of various ages, education levels, careers, salary, or whether they owned a home. Respondents aged 40–49 and 60–69 also perceived lower pollution from renewable energy than other age groups ($p = 0.0393$ and $p = 0.0779$, respectively). **Conclusion:** With a broader, more diverse population in future work, we anticipate more variability in responses, but similar trends. The prospect of implementing renewal energy is positive and suggests that policy makers should supply incentives, promote education, and invest resources for effective implementation. The Bangladesh government can support studies to understand peoples' perception of alternative energy sources and explore socially suitable interventions to address climate change.

Keywords: Recommendations- renewable energy- perceptions- policy- sustainable

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Introduction

Worldwide, combustion of fossil fuels for electricity production, heat, transportation, and industry represents more than 80% of the primary energy supply [1], and have increased by more than 90% since 1970 [2]. Conventional sources of energy including coal-fired, nuclear power, oil, and natural gas release impurities into the environment [3], and pollution resulting from these energy sources is a leading cause of climate change and a principal threat to environmental integrity and public health [4]. For example, in the Great Lakes Region of North America, coal burning has released so much mercury into the air, and has settled into the Great Lakes, that human consumption of fish from the Great Lakes poses health risks [5]. Additionally, CO_2 emissions from burning fossil fuels through transportation, electricity, and industry account for 77% of greenhouse gas emissions in the United States (US), and has comparatively increased since the 1990s, although emissions have fallen slightly since 2006 (EPA 2020).

In addition to environmental risks, conventional energy production is costly. In the US, the amount of money spent to consume energy reached $1.14 trillion USD [6]. This

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monetary value does not include the economic toll of depleted natural resources, environmental degradation, and air and water pollution. Supplies of several fossil fuels are limited and rising prices are causing economic turmoil throughout the world. Energy expenditures could be more economically sound if they were locally derived and cleaner.

Alternative energy sources such as solar and wind power, or renewable biomass resources have the potential to increase energy production without the combustion of fossil fuels, and are being considered more prevalently on a global scale by many governments [7]. For instance, over the past decade, solar power generation has gained a 46-fold increase, more than any other energy source in the US, but still accounts for approximately 1% of energy use (EIA 2019). Other renewable sources from wind, hydroelectric, or biomass only account for < 10% of energy in the US (EIA 2019). Renewable energy sources may have the potential to fulfill increasing energy needs around the world, but change from conventional sources may be challenging for governments and the public to accept due to a perceived disruption in the current, established way of life [8]. As such, advancements in the use of renewable energy may be overcome by viewing this issue as predominantly social, rather than technological [8]. Renewable energy should be a demand of the time. It should be a democratic option to meet energy needs of societies, and also responsibly sustain the earth's resources for future generations [9]. In fact, evidence shows that growing publicinterest in renewable energy sources and awareness of negative environmental and health risks caused by conventional energy sources can prompt legislation aimed toward cleaner energy consumption. For example, in Michigan, USA, public pressure for cleaner energy incited policy (i.e., Michigan's Clean, Renewable, and Efficient Energy Act) to have 10% of net energy in the state come from renewable energy sources, and increase thereafter. Some local cities aimed for more ambitious goals of a much higher proportion of energy supplied from alternative sources including solar, water, wind, biomass, geothermal energy and energy from landfill gas.

To gain momentum for developing initiatives to reduce pollution caused by fossil-fuel combustion, and increase advancements in the use of cleaner energy, societies need to overcome political, economic, and social barriers to acceptance and use of alternative forms of energy [8]. Once such way is for policy-makers to first understand knowledge and perception of community use of renewable energy on a local scale. It is evident that, there are few studies on knowledge and perception of community on use of renewable energy have been done, however, research demonstrates correlations between perception factors and preferences for renewable energy policies [10]. To that end, there is a need to research the benefit of renewal energy at the local community level.

Objectives

Our goal for this study was to understand how communities in west Michigan, USA perceive use of fossil fuels compared to alternative energy sources in terms of availability, cost, and risks to the environment and public health. Specific objectives were to i) understand the knowledge of citizens in west Michigan, USA about renewable energy, ii) explore the perception of West Michiganders about renewable energy, and iii) recommend ways to enhance use of cleaner energy sources in order to mitigate negative environmental and public health risks.

Study Area

The study occurred primarily in Ottawa and Kent counties in west Michigan, USA (Figure 1). This geographic area represents the fastest growing area in Michigan, according to census data. According to the US Census Bureau (2019), the population of Ottawa County (1488 km^2) is nearly 292,000; the population of Kent County (2257 km2) is approximately 657,000 [11]. The land use in this area was 65% agricultural land, 8% urban, and 27% deciduous and coniferous forests [12], but urban areas associated with the city of Grand Rapids represent more of the area within Kent County. Elevations range from 177–255 meters above sea level (USGS 2017). The climate in this region is influenced by Lake Michigan, which moderates fall temperatures, but also may contribute to heavier snowfall and cooler spring temperatures than areas further from the lakeshore. Mean summer temperatures in southwest Michigan average 14 to 23°C, and winter temperatures typically average -7 to 0°C [13].

Materials and Methods

We developed a survey consisting of 24 questions aimed at collecting demographic information and understanding knowledge and perceptions of alternative energy use in west Michigan (Appendix 1, 2). Individual identity remained anonymous. This survey was approved by the [Grand Valley State University (GVSU) Institutional Review Board #20-118-H] and was designed for electronic dissemination (online using Qualtrics software) as well as in-person dissemination (mail surveys using paper and sent through the US Postal Service) as a response option for those individuals without access to the internet. We aimed to recruit participants from several demographic backgrounds by targeting employees from GVSU (which may include individuals who reside outside Ottawa and Kent counties), and residents of Ottawa and Kent counties. Three recruitment methods were used, including obtaining email addresses of GVSU employees, advertising the survey through social media, and mailing a recruitment letter to county residents.

Using GVSU employee email addresses obtained through the Office of Institutional Analysis, we sent a request for participation in the electronic form of the survey. Our target response rate was at least 10%. Consent to participate was explained on the first page of the survey (Appendix 1). Two weeks after the initial email was sent, we sent a follow-up reminder email. Individuals were instructed to complete the survey only once.

In addition to surveying GVSU employees, we mailed a recruitment letter to 4000 randomly selected residents of Ottawa County and 4000 residents of Kent County through the US Postal Service. We secured addresses through the voter registration list on file at the County Registrar's Office. The mailing contained an invitation to participate, either electronically by using a QR code or a URL to access the electronic survey, or by completing the included hard copy and sending it back to us in a provided self-addressed and stamped envelope.

Finally, we attempted to recruit participants via social media, including Facebook, Twitter, and Instagram through GVSU's Departments of Public Health, Environmental Studies, Physician Assistant Studies, and Biology. The posted announcement contained an invitation and a URL link to complete the online survey. In all three recruitment methods, the survey contained informed consent information and requested only one response, if they obtained recruitment from multiple sources (social media, email, and mailings).

Survey questions included information about demographic characteristics (e.g., age, gender, education, employment, salary, and household), location (e.g., postal code), perceptions of cost and risk of using energy from fossil fuels or alternative sources, and thoughts on energy-related policy (Appendix 2).

We collected responses for 3 weeks after the initial participation invitation, compiled all information from Qualtrics surveys and mailed-in surveys in an Excel spreadsheet, and worked with the GVSU Statistical Consulting Center to analyze the data. We quantified frequency and descriptive statistics for response variables, and ran logistic models on categorical response variables to quantify maximum likelihood estimates for determining demographic factors (independent variables) related to various perceptions of energy use (response variables). We used an a priori alpha value of 0.1 because of the bias in specific demographics. By setting alpha = 0.1, we reduce the likelihood of making a type II error (failing to reject the null hypothesis when it is actually false). Finally, we used ArcGIS v 10.4.1 software (Environmental Systems Research Institute, Redlands, California) to map the spatial distribution of responses and qualitatively assess the distribution of respondents, and the distribution of their perceived knowledge and use of alternative energy sources.

Results

Presentation of Data

Demographic Characteristics of Respondents

We received responses from 313 individuals. Based on the 2019 Census data of Kent and Ottawa counties, the demographic characteristics of our sample are similar in regards to ethnicity, age, gender and ownership of housing while there were differences in household income and education [11]. The ethnicity of both Kent and Ottawa counties is predominantly white/Caucasian, 82.2% and 92.6% respectively. Our sample fell between

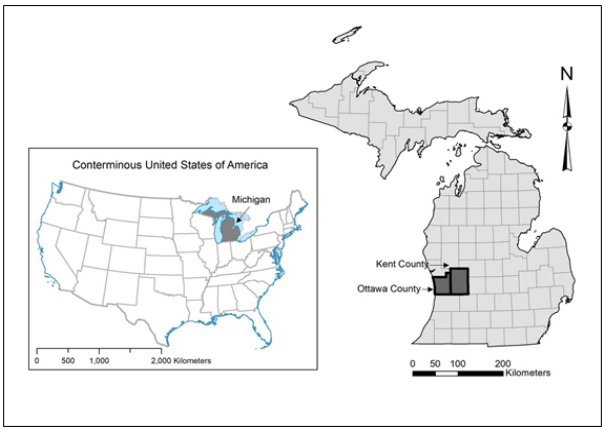

Figure 1. Location of Ottawa and Kent counties in west Michigan, USA.

these percentages at 90.6%. Approximately 17% of our sample self-reported as 65 years of age or greater while this age group represented 14.1% of Kent County and 15.5% of Ottawa County. A majority of our sample was female (59.6%), similar to that of Kent (50.7%) and Ottawa (50.6%) counties. A majority of our respondents resided in an owned home (86.6%) which is slightly higher that the population of Kent (69.8%) and Ottawa (77.7%) counties. Our sample self-reported an education level of a high school graduate or greater at 99%, similar to Kent (90.7%) and Ottawa (93.0%) counties. However, 74.8% of our sample had at least a bachelor's degree while Kent and Ottawa counties reported a much lower percentage in the 2019 Census, 35.7% and 34.1% respectively. The median range of household income in our sample ($75-99,999)

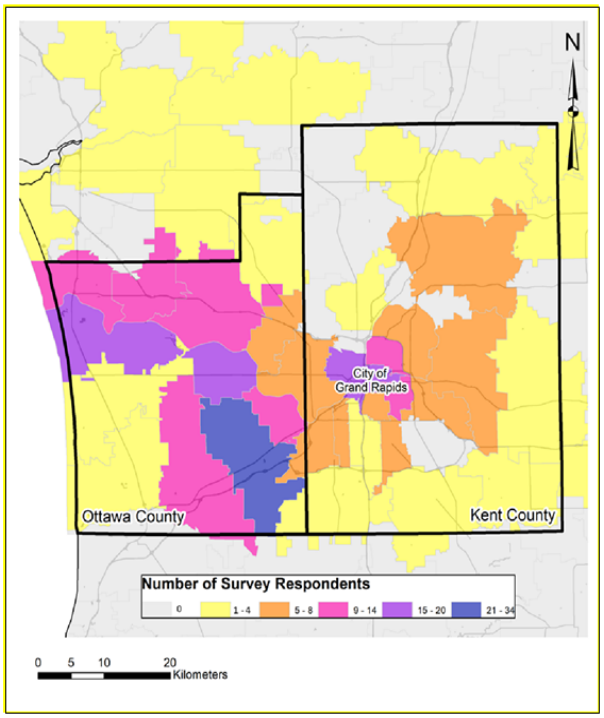

Figure 2. Spatial Distribution and Number of Survey Respondents (n = 313) in west Michigan, USA.

was higher than then median income reported for both Kent ($63,000) and Ottawa Counties ($69,3000) in 2019 [11].

Energy Usage

More than 93% of respondents reported using electricity as a source of energy in their homes. Nearly 90% of respondents also reported using natural gas or propane (3%) as an energy source. Only 10% of respondents reported using renewable energy sources in their homes. These renewable sources were generally combined with use of electricity and gas. Renewable sources were reportedly primarily from wood.

All ages of respondents use electricity as a source of energy in their homes, but a higher number of older (60+) respondents use alternative sources of energy than younger respondents. Greater than 12.5% of people older than age 60 use alternative sources of energy. Results suggest a similar distribution between males and females between use of electricity and alternative forms of energy. People with no college degree use more alternative sources of energy than those with some college or higher. People with a 4-year degree more likely to use electricity ($p = 0.0560$). People with income ranging from $50,000 - $74,999 are also more likely to use electricity than other sources ($p = 0.0425$). A higher percentage of retired people use non-electric sources of energy. A higher percentage of respondents who have lived in their homes more than 10 years use non-electric sources of energy than those who lived in their homes for fewer years. Specifically, home-owners use gas as a source of energy ($p = 0.0068$). Respondents did not differ among any demographic characteristics in their use of renewable energy sources.

Cost of Renewable Energy

Females tend to perceive renewable energy as less costly than other sources ($p = 0.0636$). People who have lived in their homes 4–6 years tend to perceive renewable energy as more costly than those who have lived in their homes for different amounts of time ($p = 0.0802$). People who have lived in their homes for 10–15 years tend to perceive renewable energy as less costly than those who have lived in their homes for different amounts of time ($p = 0.0802$).

Effects of Energy Sources on Human Health

Middle-aged people ranging from 30–59 years were 23–44 times more likely to perceive negative health risks from using fossil fuels ($p < 0.05$), whereas people < 30 years old or > 60 years old did not. People with incomes ranging from $35,000 - $49,000 and $75,000 - $99,000 also perceived negative health risks from using fossil fuels ($p = 0.0647$ and $p = 0.0615$, respectively). People in various professions or having different levels of educating did not differ in their perceptions of health risks from using fossil fuels. None of the demographic groups perceived negative health risks from using hydroelectric power or renewable energy sources.

Perceived Knowledge of Renewable Energy

Females were 3 times as likely to perceive little to no knowledge of renewable energy than males ($p = 0.0001$). People who have lived in their homes more than 20 years also perceived little to no knowledge of renewable energy. There were no differences in perceived knowledge level among respondents of various ages, education levels, careers, salary, or whether they owned a home.

Perceptions of Sustainability

Females and respondents with graduate degrees perceived use of renewable energy sources as sustainable ($p = 0.0545$ and $p = 0.0078$, respectively). Females were twice as likely to report perceptions of sustainability than males. And respondent with graduate degrees were 5 times as likely to perceive renewable energy as sustainable than those with some college. Respondents with graduate degrees also perceived that use of renewable energy reduced pollution compared to other energy sources ($p = 0.0039$). Respondents aged 40–49 and 60–69 also perceived lower pollution from renewable energy than other age groups ($p = 0.0393$ and $p = 0.0779$, respectively). Most respondents perceived fewer health risks from use of renewable energy than other sources. Specifically, females ($p = 0.0122$), those with graduate degrees ($p = 0.0133$) perceived fewer health risks. Similarly, young respondents 18–29 and those > 60 years old tended to perceive fewer health risks from using renewable energy than other age groups. Perceptions of health risks from using renewable energy did not differ among respondents with different careers.

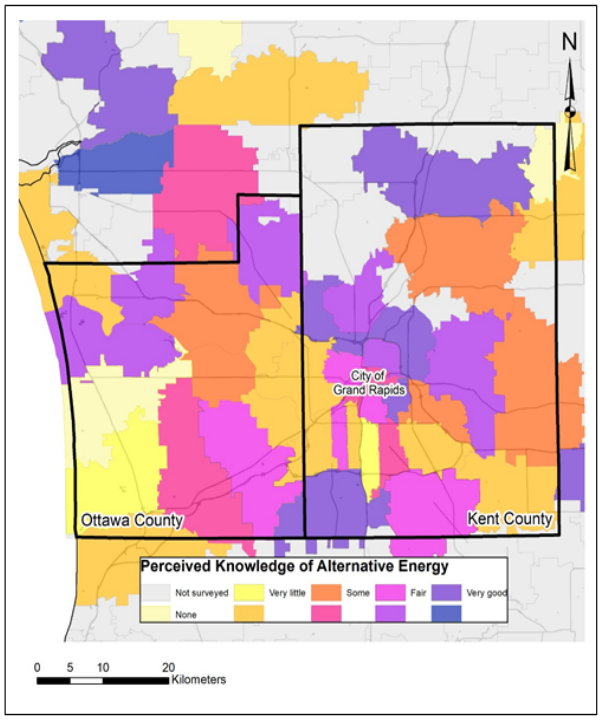

Figure 3. Spatial Distribution of Perceived Knowledge of Alternative Energy Costs, Risks, Benefits, and Use among 313 Respondents to a Survey Implemented in Winter 2020 in west Michigan, USA.

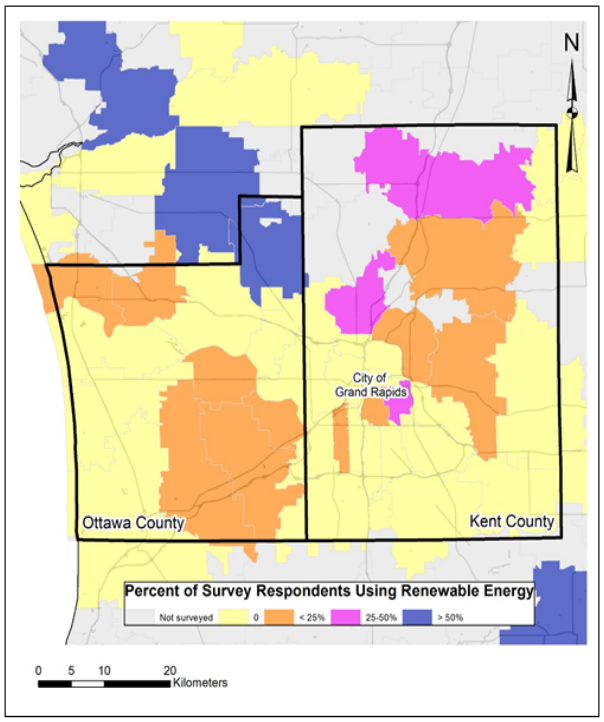

Figure 4. Spatial Distribution of the Use of Renewable Energy Sources (primarily wood) among 313 Respondents to a Survey Implemented in Winter 2020 in west Michigan, USA.

Perceptions on Investing in Renewable Energy

Respondents with a graduate degree ($p = 0.0012$), homeowners (0.0705), and those with incomes < $35,000 ($p = 0.0619$) perceived investing in renewable energy as wise. However, respondents who have lived in their homes more than 20 years did not agree that investing in renewable energy was wise ($p = 0.0362$).

Spatial Distribution of Responses

The majority of responses were from Ottawa county and within the city of Grand Rapids (Figure 2). Nearly all respondents reported using electricity as their primary source of energy. The distribution of responses covered the majority of the area of Ottawa and Kent counties, and a few of the responses spanned outside the county boundaries (Figure 2). These responses were likely from GVSU employees who resided outside Ottawa or Kent counties.

Generally, people who resided in the vicinity of the city of Grand Rapids, Kent County reported perceptions of higher knowledge of alternative energy than residents outside the urban area. In Ottawa County, which tends to be more rural, overall perception of knowledge was generally lower than in Kent County. Respondents outside the 2-county focus area reported higher perceived knowledge levels, however, these results may be biased due to low sample sizes in those zip codes (Figure 3). Higher perceived levels of knowledge did not appear to correlate with use of renewable energy sources, as individuals using renewable energy tended to occur outside urban areas, likely where wood resources are more available (Figure 4).

Discussion

Alternative Energy and Demographics

The demographic characteristics of the sample was generally representative of the race and gender composition of the overall population of Ottawa and Kent counties, except in the areas of income, education, and homeowner status. Our sample represented individuals with generally higher income, levels of education, and ages, likely due to the collection of survey responses from GVSU employees. Although most of the GVSU respondents resided in Ottawa and Kent counties, the study was deficient in analyzing responses from minority groups, younger individuals, and those with lower levels of education. However, our results suggested that there were no differences in perceived knowledge of renewable energy among various demographic groups including those of varying ages, careers, income, education, or whether they owned a home. Thus, it is likely that the trends in perceptions we observed in these results represent those of the general population of west Michigan.

Rather, differences among demographics were related more to use of non-electric energy sources rather than perceived knowledge about renewable energy and perceptions of health risks of conventional energy. For instance, it is interesting to note that alternative energy use is higher among older residents of west Michigan, residents who have lived in their home for a longer period of time, and those who live on the outskirts of urban areas (Figure 4). Additionally, individuals with no college degree use more alternative sources of energy than those with some college or higher. There are possible reasons for the observed trends in the use of non-electric energy sources. First, as wood was the most frequently-reported source of renewable energy, access to wood is more likely away from metropolitan areas. Second, research shows that individuals living in rural communities tend to be older and less educated than those living in urban areas [14]. Third, knowledge of renewable energy did not necessarily correlate to use of renewable energy. For instance, although older and less educated individuals reported more frequent use of renewable energy, their perceived knowledge about renewable energy was no different than other demographics. Thus, use of alternative energy among likely is more related to convenient access and to wood than individual age or education specifically.

Females and individuals with higher education tended to perceive alternative energy as more sustainable and less of a health risk than conventional energy sources. Research suggests that education is a key determinant of renewable energy demand, because environmental awareness tends to be positively correlated with level of education [15]. Females tend to be the mainstream users of household energy and influence or are responsible for paying energy expenses. Additionally, many women's organizations such as WEDO (wedo.org) advocate for green energy and environmental sustainability [16].

Reviewing the above trends, we identified following

social barriers in respect to renewable energy knowledge, attitude and practice.

Social Barriers to Alternative Energy

Nearly 95% of respondents indicated that they would consider using alternative energy sources if they were available and affordable. Specifically, younger generations and female groups seem to be receptive to use of alternative energy sources because they are sustainable, environmentally friendly, and less risky to human health. The survey results suggest that if alternative energy sources were available and affordable, people would use them. However, there are some potential barriers to advancing use of alternative energy. First, as use of renewable energy sources was positively correlated with education, it would be beneficial for energy companies and governments to support educational materials and make them available in schools or media sources. Youth-friendly social media platforms may be effective in educating younger demographics. As females reported lower perceived knowledge of alternative energy sources, but a higher interest in using them as sustainable sources, policy makers should provide information to female-based groups on social media, magazines, or support sustainable energy use for manufacturing products that are geared toward females. A community governance intervention would be effective to implement educational programs at a societal level.

A second barrier to use of alternative energy is a change in the societal paradigm for energy use. Our results suggest that although people may be aware of the environmental and health benefits of using renewable energy sources, a change in conventional energy use would potentially disrupt an established and convenient lifestyle [8]. Access to alternative energy sources is currently inconvenient for many residents, especially those who live in urban areas where wood is not available, and solar panels or other forms of renewable energy are not established.

Third, our results revealed that some respondents take the NIMBY (not-in-my-backyard) view on alternative energy use. Several individuals shared that they are interested in using renewable energy, but do not want to install any infrastructure such as solar gardens or wind farms close to their residence [17]. This is a common view across societies; generally, people understand that renewable energy has merits, but they perceive negative circumstances if they are within close proximity to some alternative sources.

A fourth barrier includes financial responsibility. Our results revealed that there is generally uncertainty about the cost of establishing and using renewable energy. Although females and those who have owned a home for 10–15 years perceived use of renewable energy as costly, many respondents commented that an initial investment would be more costly. People who have lived in their homes for less time or more time viewed alternative energy as more costly, probably because new homeowners have undergone a financial burden of purchasing a home, and older homeowners who have already gained equity may not be willing to invest more in their home. Nonetheless, the interest in using alternative sources is evident in west Michigan and alternative energy use would likely be more widespread if supported by local, state, or federal policies and subsidies.

Lessons for Bangladesh

Bangladesh had made remarkable progress in many areas like reducing poverty from 43.8 to 14.8 percent [18]. The country has accomplished many important milestones of Millennium Development Goals like immunization of children. It is also making progress in meeting Sustainable Development Goals. At this phase, a comprehensive and balanced development agenda for sustainability is needed, since sustainability is interrelated to many factors of societal development. For example, policy wise, Bangladesh is still encouraging coal-based power plant to meet energy needs while the country has huge potential to generate solar power. The following information will be helpful for Bangladesh to improve its energy structure and program intervention:

First, scientific research studies should be conducted involving 3rd party research to assess renewable energy use and peoples' perspectives on various sources. The Government of Bangladesh should have a specific committee to implement study findings. Second, a collaborative effort between government and non-government organizations is needed to create awareness about renewable energy use, implementing sustainable energy programs, and conducting regular evaluation/ monitoring. We recommend involving a hierarchy of administrative units (8 Divisions, 64 Districts and 522 Upazilas (subdistricts = US County) to collaboratively develop energy policies at multiple levels of government. It may be helpful to use a bottom-to-top approach where local communities are involved in assessing energy needs and designing program to develop sustainable programs. Finally, a community governance should be established to monitor the progress and challenges of the renewable energy program. The government of Bangladesh should encourage such monitoring so that the community take the ownership to increase and sustain the renewable energy use.

Conclusions and Recommendations

During the period of 1999–2018, the Global Climate Risk Index placed Bangladesh in the top 10 countries most affected from extreme weather events associated with climate change [19]. Research shows that use of renewable energy sources is effective in reducing fossil fuel emissions, which contribute to greenhouse gasses, climate change, and public health risks [20]. The prospect of implementing renewable energy in west Michigan is positive based on the sample of respondents. Continued work on this project will target responses from more diverse demographics to characterize perceptions from a sample representing the actual demographic composition of Ottawa and Kent counties. With a broader, more diverse population in future work, we anticipate more variability in the responses, but similar trends. Our results suggest that policy makers should supply incentives, promote education, and invest

resources for effective implementation. The Bangladesh government can support studies to understand peoples' perception of alternative energy sources and explore socially suitable interventions to address issues associated with environmental degradation, public health concerns, and climate change.

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