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Research Article

Knowledge, belief, and attitude of Bangladeshi youth toward the development of nuclear power

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Abstract

Public support is one of the major challenges for maintaining a sustainable nuclear power program for any country. Although Bangladesh's decision to build its maiden nuclear power plant (NPP) has received significant scholarly attention, the study regarding public perception is largely ignored. To fill this gap, this study investigated how Bangladeshis view the government's decision to build NPPs. The study evaluated Bangladeshi youth's knowledge, belief, and attitude toward the development of nuclear power. Applying the survey research technique, we found that 49% of the 450 respondents were positive toward NPPs, while 12% had no idea about NPPs. Women, in comparison to men, were found to have less knowledge of nuclear energy. Additionally, 41% of the respondents believed that the decision for establishing the country's first NPP at Rooppur was right. However, 54% of the respondents expressed concerns over the safety, security, and sustainability of NPPs. Most importantly, a significant distrust among the respondents was observed in the capability of the regulator and operator for maintaining the NPP in a safe, secured, and sustainable manner. The study concludes that more policy actions are necessary to increase public support for nuclear power.

Keywords

Public perception, Nuclear power, Survey technique, Rooppur, Youth, Policy recommendation

1. Introduction

Over the decades, there has been a significant increase in the number of countries around the world, which have been considering building nuclear power plants (NPPs) for ensuring energy security, while maintaining climate resilience. Nuclear energy is currently being generated from 443 reactors in 32 countries, providing only a 10% share of the global electricity demand (IAEA 2020), which was 13% before the Fukushima accident (IEA 2021). To increase the nuclear energy production from the decreasing trend, one of the most significant tools is positive public perception (Goodfellow et al. 2011). Public perception about nuclear energy has always seen two faces – the face of immense promise and the face of peril, which result in forming two groups – supportive and protesting (Bisconti 2018). Therefore, public support is considered as a universal driver for the sustainable operation of reactors and the expansion of nuclear power programs (Park 2019). Thus, evaluating public opinion has historically been a critical proponent when it comes to the development of NPPs. Several reasons underpin the significance of public opinion.

Firstly, having significant public support ensures that an NPP is being built on social consensus, which plays a crucial role in determining whether nuclear energy will be incorporated into the national energy policy for electricity generation (Goodfellow et al. 2011). Secondly, involving the public in every stage of an NPP planning and development not only helps to clarify misunderstanding and mistrust, but also increases public support (Goodfellow et al. 2011). Thirdly, negative public opinion toward the development and operation of NPPs can cause risks for the nuclear industry. For example, the construction of new NPPs at Sizewell B and Druridge Bay in the United Kingdom have experienced significant delays and cancellation of the project, respectively, due to negative public opinion (Goodfellow et al. 2011).

When it comes to public opinion, a large number of the literature has analyzed a few latent variables such as knowledge, belief, and attitude of the public (Stoutenborough et al. 2013, 2015, Wang et al. 2013, He et al. 2014, J. Wang and Kim 2018, Bauer et al. 2019, Anbumozhi et al. 2020, Murakami et al. 2020). These latent variables have distinct characteristics and interrelationships (Joubert 2018).

'Knowledge' refers to the level of understanding of nuclear science and technology (Stoutenborough et al. 2013, Arikawa et al. 2014). 'Belief' affects one's sense of moral obligation to act positively or negatively depending on experiences, facts, observed events, and access to the right information. 'Attitude' is a mindset or mental readiness toward any object or situation that leads to act in a particular way (Manandhar 2020). Public attitude is usually determined by knowledge and belief and it can be positive, negative, or ambivalent (Joubert 2018). It changes across time and places (Stoutenborough et al. 2013). According to social exchange theory, considering cost-benefit analyses of nuclear energy and comparing with alternatives, supportive or hostile attitudes are not fixed, rather evolved (Hou et al. 2019). According to one study, people living near NPPs have more positive attitude toward nuclear energy than the far living people (Bisconti 2018).

Some argued that the availability of knowledge shapes public attitudes and perceptions toward nuclear energy (Yu et al. 2012, Stoutenborough et al. 2013). Knowledge shapes attitudes and perceptions, irrespective of whether such knowledge is valid or not (Heider 2013). For instance, lack of knowledge and clear understanding of nuclear power and preoccupation with the destructive image of nuclear accidents may lead to negative public perceptions (Bauer et al. 2019, Park 2019). Others argued that attitudes toward nuclear energy are functions of knowledge and beliefs (Kim and Kim 2017). Similarly, many argued that perceptions on nuclear energy, which are shaped by knowledge, belief, trust, misunderstanding, and even myths about nuclear energy, can be significant determinants for public attitudes (Ho et al. 2014).

Scholars insisted that "the biggest shifts in public opinion on nuclear energy issues coincide with major nuclear accidents" (De Boer and Catsburg 1988). After the 2011 Fukushima accident, many European countries e.g., Germany, Italy, Switzerland, and France, have either shut down nuclear reactors or reduced their use of nuclear energy as a response to the public backlash (J. Wang and Kim 2018). In Japan, site selection for new nuclear facilities or expansion of new nuclear reactors has now become much more difficult than before.

However, the development of NPPs may experience support or opposition from the national and international arena (Brunnengräber et al. 2015). The degree of the supportive or opposing attitude of the public is mainly dependent on the efforts to clarify people's perceptions of risks and benefits involving nuclear energy. As public opinion varies across time and places, it often leads to different responses to different countries.

Bangladesh is building its first NPP at Rooppur, located in Pabna, some 160 kilometers North of the capital, Dhaka. Since independence, Bangladesh had been facing a huge deficit in its supply of electricity to meet the country's daily needs. Being one of the world's lowest energy consumption countries (512kWh/person/year) (BPDB 2020, WPR 2020), Bangladesh has historically relied on fossil fuels for power generation, of which 50% comes from natural gas, following 35% from imported oil, 8% from coal, 5.5% imported from India through regional connectivity, and 1.5% from renewable sources including hydro. Most worryingly, the biggest power supply source – 'natural gas' – is being depleted fast and is believed to be exhausted by 2030 (Shetol et al. 2019). Thus, the incumbent government, after assuming power in 2009, put the highest priority on 'electrification for all' by 2021 and decided to harness nuclear power to meet the country's energy needs.

Bangladesh is now constructing generation III+ VVER-1200 model twin reactors with a total electric capacity of 2400MW at the Rooppur site with technical and financial assistance from the Russian State Atomic Energy Corporation (Rosatom) (Ashraf and Islam 2018). As of September 2021, the physical progress of the construction is about 30% despite fully strengthening the regulatory body, the establishment of a radioactive waste management company, and an emergency response center. The first and the second reactor are expected to be operational by 2023 and 2024, respectively (Islam et al. 2021). Bangladesh aims to generate a 10% share of the total electricity using nuclear technology (MPEMR 2016). Bangladesh has also declared to develop its second NPPs site in the Southern part of the country, as part of an extended nuclear power development program.

Bangladesh government's decision for building the country's first NPP has received significant scholarly attention. Available studies broadly focused on the challenges and prospects of nuclear energy for sustainable socio-economic development (Bhowmik and Barua 2012, Siddiky 2015b, Islam and Islam 2016, Karim et al. 2018). Since the inception of the Rooppur project, experts largely found themselves in one of two major camps: nucle-

ar energy optimists (who support the government's decision) and nuclear pessimists (who oppose it) (Siddiky 2015a, Karim et al. 2018, Ahmed et al. 2020). However, the question regarding public perception has remained relatively less explored. This study, therefore, investigates how the public in Bangladesh view the government's decision to build NPPs.

At present, about 30% of the total population of Bangladesh is young who are aged 15–30 (BBS 2019). Our study is based on an empirical survey, which mainly includes Bangladeshi youth who are aged between 18 and 30. The reasons for choosing to evaluate the youth's perceptions are manifold. First, the youth are the foundation of a nation, and they are future leaders and policymakers. Their perceptions, attitude, and behavior significantly affect the life of a nation. Second, the country has a history of multiple youth-led movements that had accelerated several changes including the downfall of the military dictator. The youth are very active in social and electronic media, hence remain up-to-date about the major policy issues in a country. Third, the youth are most receptive and mainly responsive to any major policy changes, thus playing the role of a major policy influencer (Kabir and Greenwood 2017). Finally, the ability of the youth to get united and raise their voice against a common policy issue is vast, which might cause unexpected events and delay the implementation of any major policy decision such as the NPP construction.

The goal of this study is two-fold. The primary objective of this study is to assess the knowledge, belief, and attitude of Bangladeshi youth toward nuclear energy. The secondary objective is to explore the underlying factors behind their positive or negative perception by testing a series of hypotheses. The paper is divided into four sections. Following this introductory part, the second section presents hypotheses and research designs. The third section provides the results and discussion, and the final section draws some conclusive findings and policy recommendations.

2. Methodology

This research began by carefully designing a Likert-scale, multiple choice, and yes/no questionnaire to ask individuals across the country to have their opinions toward the construction of the first NPP in Bangladesh. The questionnaire was constructed after an extensive literature review and the implementation of a Focus Group Discussion (FGD). Five hypotheses were formulated for our cross-sectional study and data were analyzed using descriptive statistics and Chi-squared tests. The flow diagram of the research process is presented in Fig. 1. Detailed methodology is discussed in subsections 2.1 to 2.3.

2.1. Hypothesis formulation

The hypotheses for this study were formulated after an extensive review of existing studies on the public perceptions of nuclear power in many different contexts. Variations in the public perceptions were found to be contingent upon a variety of factors. After surveying the existing literature, we found that the public perceptions of nuclear power are significantly affected by at least four different factors such as gender, risk and benefit calculation, trust in government, and geopolitical circumstances. These factors have eventually led to the formulation of hypotheses.

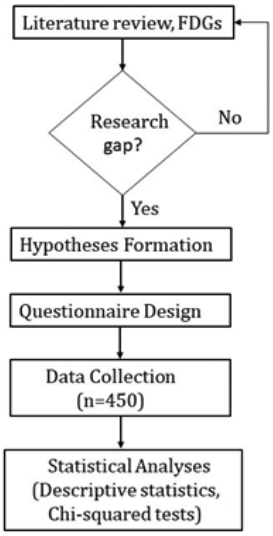

Figure 1. Research process.

A series of studies have found a significant relationship between gender and perceptions of nuclear power. Simon (2013), using the data from Eurobarometer 72.2, explored that, women largely hold negative perceptions toward nuclear power and are more likely to oppose nuclear power than men, due to their gendered experiences such as living with children. Other studies explored similar findings on women's negative perceptions toward nuclear power relating to gendered experiences, profession, and level of awareness (Sundström and McCright 2016). In contrast, Whitfield et al. (2009) found that perceptions and attitudes in the United States toward nuclear power do not vary based on gender, age, education, or income. Notwithstanding the differences, it can be inferred that socio-demographic factors (i.e., gender, education, occupation, etc.) play a significant role in shaping public perception toward nuclear power. This realization leads us to formulate our first two hypotheses.

Hypothesis 1: There exists a significant relationship between the acceptance of the Rooppur nuclear power plant and gender.

Hypothesis 2: There exists a significant knowledge gap between men and women on nuclear energy.

Another significant factor affecting people's beliefs and attitudes toward nuclear energy is the risk-and-benefit perceptions involving nuclear power. Several studies found that the people's perceived risks and benefits involving nuclear energy are strongly relevant to the public acceptance or rejection of NPP development in different contexts such as the United States, United Kingdom, and China (Huang et al. 2013, Dai et al. 2019, de Groot et al.

2020, Wu and Huang 2021). This factor, thus, leads to the formulation of our third hypothesis.

Hypothesis 3: The risk-and-benefit perceptions on nuclear power strongly relate to the youth's belief.

Although the existing literature has not explored the effect of the geopolitical scenario on the public perception and attitude toward nuclear power in a country, the current study insists that a country's geopolitical dynamics may have a significant impact on the public attitude regarding NPPs. While the Bangladesh government's decision to choose its longstanding ally, Russia, as the nuclear vendor, is widely regarded as a smart move (Ashraf and Islam 2018), the government's decision to involve India, bilaterally and trilaterally, in the Rooppur project, has generated debates and suspicion among the experts and the public, especially the youth. India's geopolitical location surrounding Bangladesh in three sides, ups-and-downs in the Indo-Bangladesh relations, and pro-India and anti-India sentiments revolving around a series of disputed issues between these two neighbors, underpinned the suspicion and raised concerns over India's involvement in Bangladesh's Rooppur mega project (Rana and Islam 2021). Against this backdrop, we formulated our fourth hypothesis on the effect of geopolitical scenario on the youth's attitude on nuclear power.

Hypothesis 4: The youth's attitude toward international cooperation for nuclear power implementation program strongly depends on the geopolitical scenario of the country.

It is important to note that the risk-and-benefit perception is associated with trust in government, as highlighted by several studies in varied contexts (Siegrist et al. 2000, Xiao et al. 2017, Ryu et al. 2018, Hassan et al. 2021). These studies have also found that lack of trust in government and its regulatory capacity along with the country's poor governance may negatively affect people's risk-and-benefit perceptions. The size and extent of corruption in a county has remained as a popular indicator to understand the level of governance and trust in a government (Hough 2013). This realization leads us to formulate our fifth hypothesis.

Hypothesis 5: The youth's belief in government's departments, regulator, and operator involving in the nuclear power implementation program strongly depends on the country's corruption level and management system.

2.2. Questionnaire preparation

In this study, a questionnaire-based survey was conducted across the country from October to December 2020 to assess the knowledge, belief, and attitude of the young generation on the construction of the first NPP in Bangladesh. The questionnaire was divided into four sections. Section one consisted of respondents' socio-demographic factors i.e., gender, age, the field of education, education level, and occupation as these variables are strongly linked with respondents' knowledge, belief, and attitude. The remaining three sections comprised 27 questions related to the three latent variables i.e., knowledge, belief, and attitude. The interfacing of four areas of the questionnaire is depicted in Fig. 2.

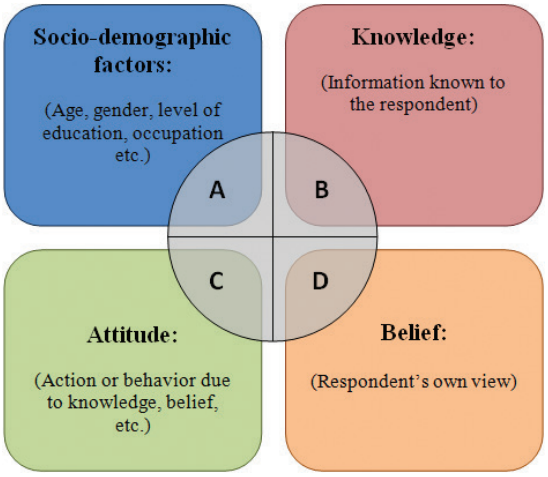

Figure 2. Interfacing of four areas of questionnaire.

Before preparing the questionnaire, the authors organized an FDG held on 6 March 2020 that brought together over 30 energy experts, policymakers, academicians, and representatives of nuclear regulators and operators. Table 1 presents the number of participants of the FGD from different stakeholders. The discussions were based on the justification and rationale of introducing nuclear power in Bangladesh, the challenges (safety, cost-effectiveness, and environmental issues) of nuclear technology, international cooperation, public participation, and criticisms. Each participant was asked to submit several questions based on the existing literature and the information based on the FDG discussion areas. Out of 50 questions collected from the participants, a list of 27 closed-ended questions was selected based on the relevance and fitness to our study objectives. We also rephrased the language in several selected questions to make them simplified and better understandable for the respondents, while keeping their original meaning intact. Thirteen, six, and eight questions were chosen related to knowledge, belief, and attitude respectively as shown in Table 2. Answering options of the 27 questions are of three types e.g., Likert scale with five options; strongly disagree to strongly agree, multiple choice, and yes/no.

Table 1. Participants' organization and respective numbers of the Focus Group Discussion (FGD)

Institution/Organization	Number of Participants
Academics (Nuclear and non-nuclear)	12
Ministry of Science and Technology	01
Bangladesh Atomic Energy Commission, Russian State Atomic Energy Agency (Rosatom), Information Center on Nuclear Energy (ICONE)	05
Bangladesh Energy Regulatory Commission (BERC)	02
Nuclear Power Plant Company Bangladesh Ltd.(NPCBL)	06
Nuclear engineering students	06
Industry professionals	03
Print and electronic media	02

Table 2. Types of latent variable, question/statement, and answering options for this study

	Category	Question/ Statement	Response Type
K1	Knowledge	What is the main source of clean energy?	Multiple choice
K2		Do you know that Bangladesh government is working toward implementing the country's first nuclear power plant named as Rooppur Nuclear Power Plant Project (RNPP)?	Yes/No
K3		Nuclear power can contribute to sustainable economic development in Bangladesh.	Likert scale
K4		The biggest concern about the Rooppur Nuclear Power Plant is….	Multiple choice
K5		Bangladesh should have skilled manpower development program and keep them up to the entire lifetime (60 years) of the Rooppur Nuclear Power Plant.	Likert scale
K6		The role of the nuclear regulatory body is very crucial for licensing and monitoring the construction and operation of the Rooppur Nuclear Power Plant. The regulatory body must be scientifically and technically competent enough and independent in decision-making.	Likert scale
K7		Bangladesh has a strong liability mechanism (payment to sufferers if any accident occurs) to face accidental situations if occurs	Likert scale
K8		The main reason for energy crisis in Bangladesh is….	Multiple choice
K9		Rooppur is suitable site for building nuclear power plants.	Likert scale
K10		Renewable energy sources (e.g., solar, wind, water) can substitute nuclear energy to generate electricity in Bangladesh.	Likert scale
K11		Per unit electricity cost produced by nuclear would be cheaper than coal.	Likert scale
K12		To increase more public support, nuclear education should be added to the secondary and tertiary education level of Bangladesh.	Likert scale
K13		Before the completion of Rooppur nuclear power plant construction and without gaining operating experiences from it, do you think the Government of Bangladesh (GoB) should go for another construction of a nuclear power plant at other site?	Yes/No
B1	Belief	Nuclear power plant is environment friendly.	Likert scale
B2		Nuclear power plant's radioactivity poses a great risk to the nearby residents.	Likert scale
B3		The construction of Rooppur Nuclear Power Plant (RNPP) will be free from corruption.	Likert scale
B4		Nuclear power plants can meet present energy crisis in Bangladesh.	Likert scale
B5		Nuclear power plant is safe for Bangladesh.	Likert scale
B6		Nuclear power plant waste is a concern for people and environment.	Likert scale
A1	Attitude	Based on Bangladesh's current socio-infrastructural condition, it is possible to maintain nuclear power in a safe, secured, and sustainable manner.	Likert scale
A2		Nuclear power plant will contribute to generate employment opportunities in Bangladesh.	Likert scale
A3		Bangladesh could tackle nuclear emergency situations during a nuclear accident.	Likert scale
A4		What is your attitude toward nuclear power?	Likert scale
A5		Bangladesh government's decision to implement the Rooppur Nuclear Power Plant project was right.	Likert scale
A6		What do you think is the main purpose behind Bangladesh's bilateral nuclear collaboration with Russia?	Multiple choice
A7		What do you think is the main objective behind Bangladesh's bilateral nuclear collaboration with India?	Multiple choice
A8		How do you perceive Bangladesh's trilateral nuclear cooperation with India and Russia?	Multiple choice

2.3. Sample size and data collection

To find out the expected number of sample size (n), equation (1) was used (Kish and Ni 1997, Kothari 2004).

$$n = \frac{z^2 p(1-p)}{e^2} \quad (1)$$

Here, n is sample size, z is 1.96 (for 95% confidence interval), p is probability (taken 0.5 for maximum sample size) and e is acceptable error (taken 5% of p). Using equation (1) and assumed data, a minimum sample size of 384 is required for satisfactory results.

The authors collected data across the country via an online platform using a snowball sampling technique due to the COVID-19 pandemic. All respondents were asked to complete all fields before submitting their online survey responses. The disadvantage of an online survey is that the generated data may have some incorrectness or bias. To offset this limitation, increasing the number of survey respondents is a popular technique. To account for the error data, the authors distributed the questionnaire to 550 participants, of which 473 respondents completed the survey. After screening the 473 responses, 450 responses were finally selected for analyzing the results.

Participants were divided into three groups based on their field of education (Science and Engineering, Business studies, and Arts, Humanities and Social Sciences) and four groups based on their occupation (Public sector, Private sector, Nongovernment organizations (NGOs), Civil societies, Media, and Others). This clustering of the respondents was done to explore possible relationships between the control and latent variables of the respondents.

Before data collection, consent was taken from each respondent and data confidentiality was ensured. Chi-squared tests were performed to check the consistencies and the biases of the results due to gender, the field of education and occupation. P-value equal to 0.05 was considered as the critical value for the hypothesis tests. Data analyses and graph generations were done using MATLAB R2017a and MS Excel.

The number of respondents and their percentages on gender, age, education, the field of education, and occupation are presented in Table 3. It is reported in Table 3 that there is sufficient diversity among the respondents in case of gender, the field of education, education level, and occupation. However, the age of most respondents (98%) is in the range of 18–45. This was done to highlight the perception of the youth since they were the target group

Table 3. Socio-demographic variables of the respondents

Key information Basic Information	No. of respondents	Percentage (%)
1. Gender		
Male	290	64
Female	160	36
2. Age Group		
18–30	422	94
31–45	20	4
45+	8	2
3. Level of Education		
Graduation or below	381	85
Post-graduation	68	15
Field of Education		
Science and Engineering	156	35
Business Studies	140	31
Arts, Humanities, and Social Science	154	34
Occupation		
Public Sector	93	33
Private Sector	96	33
NGOs, Civil Society, and Media	41	14
Others	57	20

of this study. Responses from other age groups were, therefore, omitted from the analysis. Also, most of the respondents (85%) had a graduate degree or below.

3. Results and discussion

3.1. Statistical analysis

Statistical analyses were conducted with the survey data to identify whether the sample population represents the young population of the country or not. Chi-squared tests were performed for this purpose. The gender-wise ratio was not found to be significantly different from that of the educated population of Bangladesh ($p = 0.072$). The education field-wise and occupation-wise variations were also found significantly similar to the overall population data ($p = 0.942$ and 0.128 respectively). Thus, the data were found sufficiently diverse for drawing necessary conclusions. On the other hand, the ratio of respondents based on level of education was found significantly different and thus could not be considered as a representative sample for the mass population of Bangladesh ($p = 0.001$).

Further statistical analyses were conducted to find out whether gender, the field of education, and occupation have any influence on the response of a respondent or not. The results are presented in Table 4. From Table 4, it can be observed that gender has the most significant influence on the responses of the questions among the three categories. The responses to the questions/statements based on knowledge (e.g., K1, K2, K3, K5, K10, and K11) were found to be significantly different between the two gender groups (i.e., men and women) since the p-value was less than 0.05. On the other hand, the responses on the questions/statements based on belief (e.g., B3, B4, B5, and B6) and the questions based on attitude (e.g., A4, A5, and A6) were significantly different for men and women. The responses to the questions/statements – K4, K12, B4, and A7, were found to be significantly different for respondents of different occupation groups. Finally, the field of education had shown the least association with the responses within the specified level of significance, influencing only questions/statements K1 and K8.

Table 4. Results from Chi-squared tests

Latent Variable	Question/ Statement	Gender		Field of Education		Occupation	
		Chi-Value	P-Value	Chi-Value	P-Value	Chi-Value	P-Value
Knowledge	K1	18.59	0.0003	14.48	0.025	13.87	0.127
	K2	12.26	0.0004	0.40	0.819	0.78	0.854
	K3	16.33	0.003	12.80	0.119	17.63	0.127
	K4	1.62	0.805	7.18	0.517	23.70	0.022
	K5	14.89	0.005	7.42	0.492	11.60	0.478
	K6	0.63	0.959	6.49	0.593	13.98	0.302
	K7	4.20	0.379	12.93	0.114	9.22	0.684
	K8	8.15	0.086	29.16	0.0003	9.40	0.668
	K9	2.26	0.688	12.50	0.13	11.79	0.463
	K10	18.39	0.001	8.11	0.423	11.44	0.492
	K11	10.15	0.038	6.24	0.62	14.65	0.261
	K12	3.54	0.472	13.49	0.096	26.56	0.009
	K13	2.06	0.151	5.74	0.057	4.52	0.211
Belief	B1	8.40	0.078	5.82	0.667	13.81	0.313
	B2	1.19	0.879	10.74	0.217	4.60	0.97
	B3	12.96	0.011	3.36	0.909	10.74	0.551
	B4	17.81	0.001	5.18	0.738	21.75	0.047
	B5	9.98	0.041	3.67	0.886	9.15	0.69
	B6	13.08	0.011	9.42	0.308	15.83	0.199
Attitude	A1	4.36	0.359	5.53	0.699	3.67	0.989
	A2	5.22	0.265	3.48	0.901	16.21	0.182
	A3	4.87	0.301	4.30	0.829	8.92	0.709
	A4	16.48	0.0002	5.32	0.256	5.49	0.482
	A5	19.99	0.0005	7.14	0.522	16.34	0.176
	A6	12.02	0.017	5.30	0.754	20.54	0.057
	A7	6.40	0.171	10.15	0.255	22.68	0.031
	A8	5.54	0.236	12.99	0.112	10.62	0.562

3.2. Hypothesis testing

3.2.1. Hypothesis 1

From Table 4, it can be observed that the responses to A4, which explores the attitude and the acceptance toward Rooppur NPP, were significantly different for the two gender groups ($p = 0.0002 < 0.05$). Fig. 3 illustrates the response to A4: "What is your attitude toward nuclear power?" From Fig. 3, it can be observed that on average, 49% of respondents were positive while 39% of respondents were negative toward nuclear power. Of the respondents, 12% had no idea about nuclear power. Men were found to be comparatively more positive (55%) than women (39%). This finding is also supported by the responses to A5: "Bangladesh government's decision to

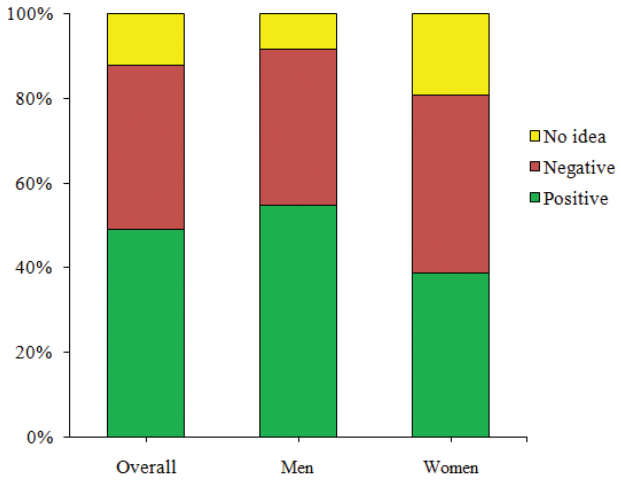

Figure 3. Cumulative and gender-wise responses to A4: "What is your attitude towards nuclear power?".

implement the Rooppur Nuclear Power Plant project was right". Although most of the respondents (41%) agreed to the statement, men were stronger supporters of Rooppur NPP (46%) than women (33%) (Appendix 1: Figs A7, A8). Thus, there is a significant relationship between the acceptance of the Rooppur NPP and the gender of the respondents. On the other hand, the field of education and occupation of the respondents did not cause any significant variation in the responses ($p = 0.256$ and 0.482 respectively). Therefore, hypothesis 1 is accepted.

3.2.2. Hypothesis 2

Fig. 4 presents the responses to K2: "Do you know that Bangladesh government is working toward implementing the country's first NPP named as Rooppur Nuclear Power Plant Project (RNPP)?". From Fig. 4, it can be observed that the majority of the respondents knew about Rooppur NPP (93%). However, men were observed to be more aware of Rooppur NPP (96%) than women (87%). The p-value is 0.0004 for K2, which is way below 0.05, suggesting that there is a significant knowledge gap between men and

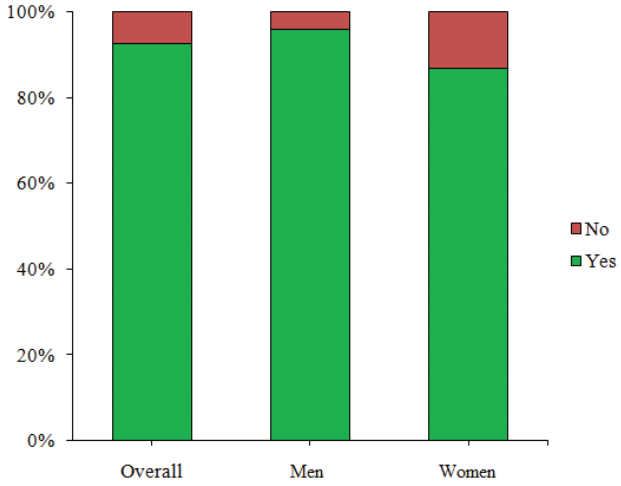

Figure 4. Cumulative and gender-wise responses to K2: "Do you know that Bangladesh government is working towards implementing the country's first NPP named as Rooppur NPP?".

women respondents regarding nuclear power. This gap can also be identified from Fig. 3, although the question is related to the attitude of the respondents. From Fig. 3, it can be observed that a comparatively lower number of men had absolutely no idea about nuclear power (8%) than women (19%). The p-value for A4 is 0.0002, indicating the existence of a significant difference in the responses of men and women. Therefore, hypothesis 2 is accepted.

3.2.3. Hypothesis 3

Fig. 5 presents the gender and occupation-wise variation in the responses to B4: "Nuclear power plants can meet present energy crisis in Bangladesh". From Fig. 5, it can be observed that there exist significant variations in responses based on gender and occupation. In general, men agreed more to B4 (74%) than women (59%). Also, B4 got comparatively more backing from jobholders in the public sector (71%) and NGOs, civil society, and media (68%), than private (65%) and other sectors (58%). Overall, 68% of respondents agreed that nuclear power can help in solving the energy problem in Bangladesh.

The survey results also suggested that the respondents

Figure 5. Gender and occupation-wise responses to statement B4: "Nuclear power plants can meet present energy crisis in Bangladesh".

have knowledge of the economic benefits of the Rooppur NPP project. About 73% agreed to K3: "Nuclear power can contribute to sustainable economic development in Bangladesh" (Appendix 1: Fig. A2). This knowledge may have resulted in a somewhat positive attitude toward the project since 78% agreed to the A2: "Nuclear power plant will contribute to generating employment opportunities in Bangladesh" (Appendix 1: Fig. A4). Yet only 41% believed that the decision regarding the implementation of Rooppur NPP was right (A5), indicating that the positivity is being suppressed by another negative factor. The explanation of this can easily be obtained from the responses to B2: "Nuclear power plant's radioactivity poses a great risk to the nearby residents". An overwhelmingly large portion of the respondents (88%) agreed to this statement (Appendix 1: Fig. A4), indicating that people are quite concerned about the possible radioactive emission from an NPP. This is again reflected from the responses to B1: "Nuclear power plant is environment friendly". Only 47% agreed to it (Ap-

pendix 1: Fig. A4), which is almost similar to the responses in A5. Also, 55% insisted that NPPs are not safe for Bangladesh (Appendix 1: Fig. A9). Thus, public acceptance is found to be strongly related to both risk and benefit perceptions. Therefore, hypothesis 3 is also accepted.

3.2.4. Hypothesis 4

Figs 6–8 present the responses to A6, A7, and A8 respectively. From Fig. 6, it can be observed that the respondents are of the attitude that economic benefit (26%) is the main reason behind the bilateral relationship between Russia and Bangladesh, following political gain (25%) and technical support (25%). A variation in response was observed between men and women. Women gave the most importance to political gain (29%) followed by economic benefit (27%), while men gave the most importance to technical support (28%) followed by economic benefit (25%). From Fig. 7, it can be observed that most of the respondents think that the main reason behind establishing bilateral collaboration between India and Bangladesh is political gain (58%). Respondents from all job sectors somewhat expressed the same opinion. The same attitude prevailed for the trilateral relationship between

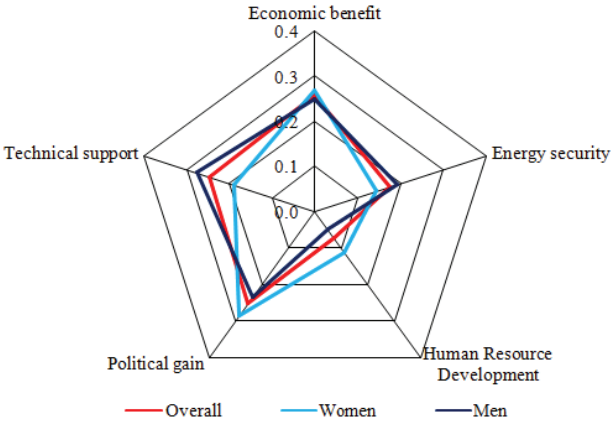

Figure 6. Cumulative and gender-wise responses to question A6: "What do you think is the main purpose behind Bangladesh's bilateral nuclear collaboration with Russia?".

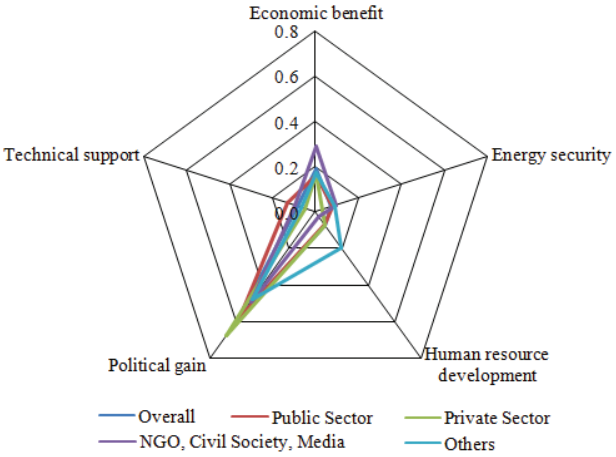

Figure 7. Cumulative and occupation-wise responses to question A7: "What do you think is the main objective behind Bangladesh's bilateral nuclear collaboration with India?".

Russia, India, and Bangladesh, as observed from Fig. 8. Around 42% opined that political reasons have undergirded the formation of the trilateral collaboration.

These results indicate that the young population has a positive impression of the bilateral collaboration between

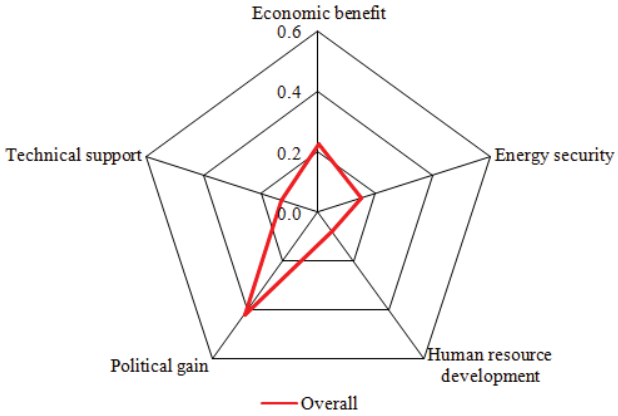

Figure 8. Cumulative responses to A8: "How do you perceive Bangladesh's trilateral nuclear cooperation with India and Russia?".

Russia and Bangladesh. They believe that this collaboration is necessary considering the economic, technical, and political benefits of the alliance. Political gain is not considered the sole purpose of the collaboration. On the other hand, the young population of Bangladesh opines that the inclusion of India in this project is almost entirely due to political gain, and they are somewhat negative towards this step. Both findings indicated that the attitude of the young population toward bilateral or trilateral collaboration strongly depends on the geopolitical scenario of the country. Therefore, hypothesis 4 is also valid, hence accepted.

3.2.5. Hypothesis 5

The respondents were sufficiently negative in their responses to B3: "The construction of Rooppur Nuclear Power Plant (RNPP) will be free from corruption", as 77% disagreed with it (see Fig. 9). Men were more doubtful of corruption-free construction of Rooppur NPP (80.3%) than women (70.0%). Thus, it can be said that the youth's perceptions of corruption influence their negative attitude toward nuclear power. This is again reflected by the responses to A1: "Based on Bangladesh's current socio-economic condition, it is possible to maintain nuclear power in a safe, secured, and sustainable manner", in which, 52% held a negative outlook (see Fig. 10). Also, the respondents were divided in their responses on K6: "The nuclear regulatory body of Bangladesh is competent and independent". Only 28% agreed to this statement, while 37% disagreed and 35% were neutral in their responses (Appendix 1: Fig. A5). This doubt is somewhat justified since the corruption index by Transparency International ranked Bangladesh as the second-lowest in South Asia (Rahman 2019). Thus, the lack of faith in the competence of the government and its organizations in managing this NPP project is significantly related to the corruption level of the country. Therefore, hypothesis 5 is accepted.

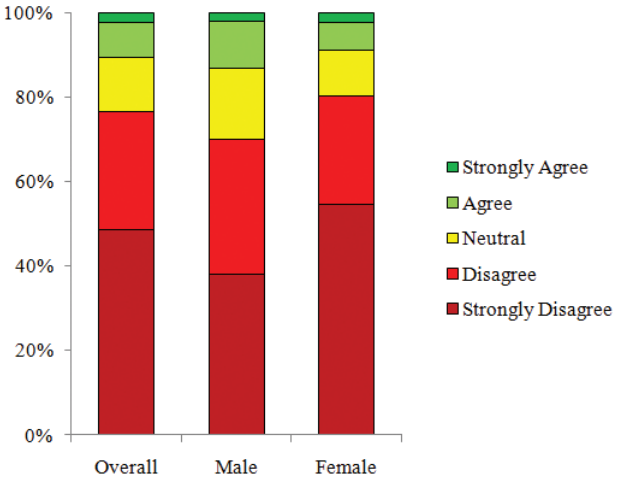

Figure 9. Cumulative responses to B3: "The construction of Rooppur Nuclear Power Plant (RNPP) will be free from corruption".

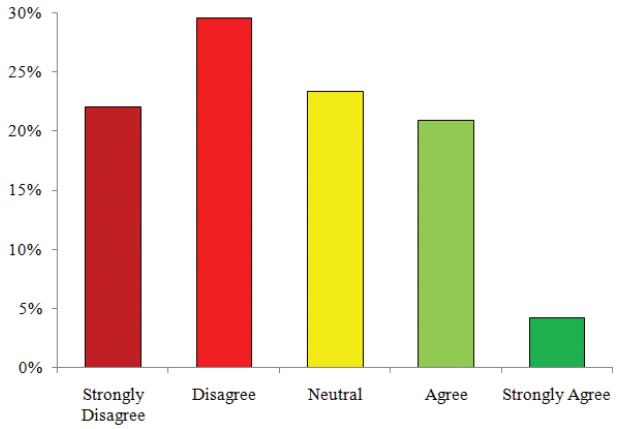

Figure 10. Cumulative responses to A1: "Based on Bangladesh's current socio-economic condition, it is possible to maintain nuclear power in a safe, secured, and sustainable manner".

3.3. Summary of key findings

The discussion and analysis of the survey results can be summarized in three key findings. Firstly, women were found to be more doubtful and unsure in their responses. Also, they were less positive toward nuclear power than men. The possible reason behind this may be the lack of knowledge of nuclear technology. Secondly, the respondents were positive toward nuclear energy and its role in the economic development of Bangladesh. However, they were highly concerned about radiation hazards and radioactive contamination to the environment. This indicated that they were not completely aware of the enhanced safety features provided in Rooppur NPP for radiation protection during a severe accident. Finally, there exists a lack of faith in the capability of the regulator and operator in the construction and management of the NPP. They also held the attitude that the project will not be free from corruption which seems general perception as they see a series of irregularities in other projects.

4. Conclusion and policy recommendations

The study investigated the youth perception toward the development of NPPs in Bangladesh. The perception was assessed based on the knowledge, belief, and attitude using survey data. The survey questionnaire was prepared through a focus group discussion with experts and different stakeholders and based on the objectives and compatibility of this research. The responses of 450 respondents were collected through an online survey. The survey data were analyzed statistically to draw generalized conclusions of the respondents' knowledge, belief, and attitude by testing the five research hypotheses.

Results revealed that the public perception varies significantly over gender. On the contrary, occupation and field of education had no significant influence on the overall responses for most of the questions. Additionally, there exists a significant knowledge gap between men and women about nuclear power. Moreover, 88% of the respondents believed that there is a risk of radioactive contamination to the environment due to the operation of the Rooppur NPP, whereas only 47% believed that nuclear power is environmentally friendly.

We found that the overall perception of the young population of Bangladesh on the construction of Rooppur NPP is neither adverse nor favorable. While 49% of the respondents were positive toward nuclear power, 41% opined that the decision regarding the implementation of Rooppur NPP was right. Although a majority of the respondents acknowledged the benefits of nuclear power, there exists suspicion and lack of trust among the young generation regarding the safety and transparency of the project. It was noticed that a positive reaction toward the bilateral cooperation between Russia and Bangladesh existed, but mixed feelings were observed for the trilateral alliance.

Based on the findings, a few suggestions can be stated to increase public support for nuclear power. Firstly, prompt actions are necessary to gain the trust and faith of the young population by widely disseminating information regarding construction, reactor safety features, radiation monitoring, and waste management systems. Secondly, special focus should be given to women as they hold a relatively negative perception of nuclear power than men. Information centres, print and electronic media, social media, nuclear energy promoters, regulators, and academic institutes should be more active to disseminate the benefits of nuclear energy to the public as well as reducing the gap in knowledge. Thirdly, nuclear education should be added to the curriculum of the secondary and the tertiary education levels of Bangladesh so that the new generation can get true knowledge about nuclear technology for developing benefit perception rather than risk perception. Finally, further studies need to be conducted to explore more generalized findings. Studies covering multiple age groups with a diverse set of questionnaires can generate more insights and will help investigate the national level perception.

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Appendix 1

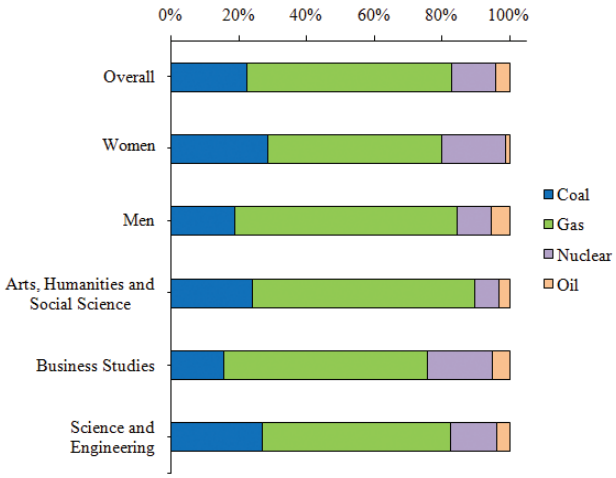

Figure A1. Responses to K1: What is the main source of clean energy?

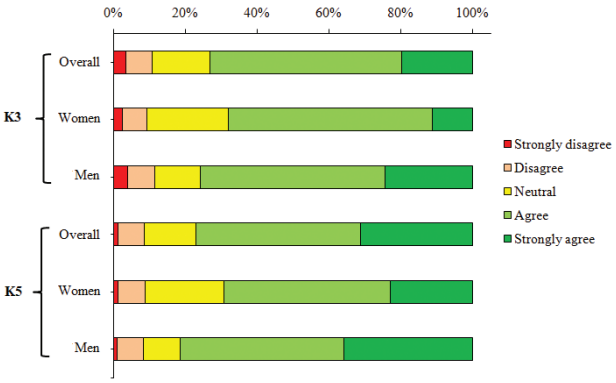

Figure A2. Responses to K3: "Nuclear power can contribute to sustainable economic development in Bangladesh", K5: "Bangladesh should have skilled manpower development program and keep them up to the entire lifetime (60 years) of the Rooppur Nuclear Power Plant".

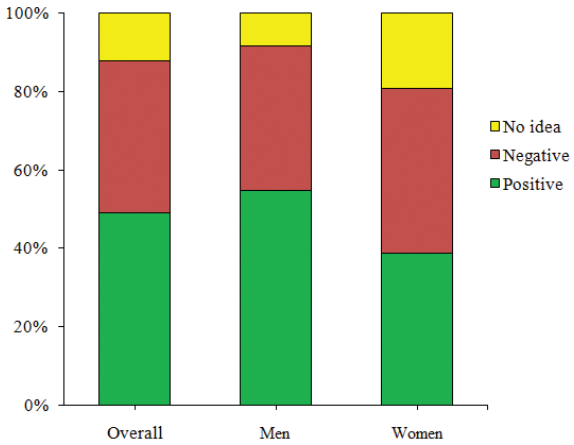

Figure A3. Responses to K4: "The biggest concern about the Rooppur Nuclear Power Plant is….".

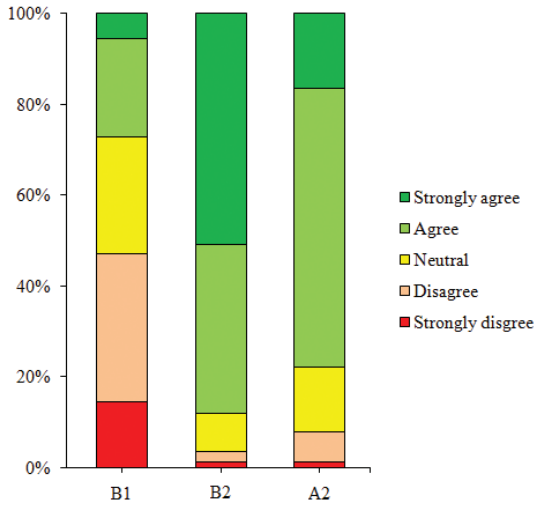

Figure A4. Cumulative responses to B1: Nuclear power plant is environment-friendly", B2: "Nuclear power plant's radioactivity pose a great risk to the nearby residents", A2: "Nuclear power plant will contribute to generate employment opportunities in Bangladesh".

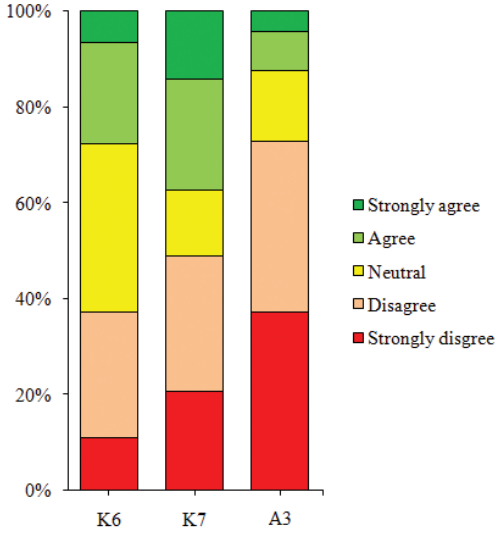

Figure A5. Cumulative responses to K6: "The role of the nuclear regulatory body is very crucial… This organization is competent and independent", K7: "Bangladesh has a strong liability mechanism (payment to sufferers if any accident occurs) to face accidental situations if occurs", A3: "Bangladesh could tackle nuclear emergency situation during nuclear accident".

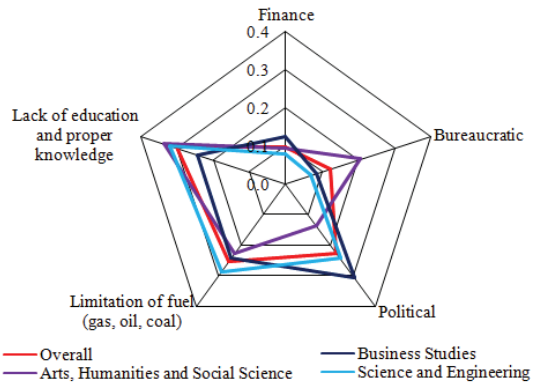

Figure A6. Responses to K8: "The main reason for energy crisis in Bangladesh is…."

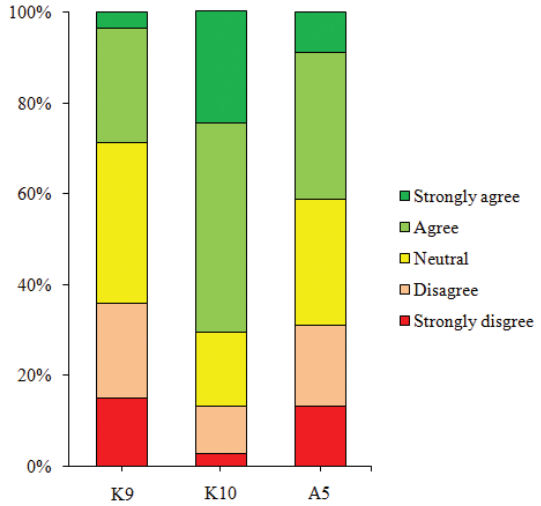

Figure A7. Cumulative responses to K9: "Rooppur is suitable site for building nuclear power plants", K10: "Renewable energy sources (e.g. solar, wind, water) can substitute nuclear energy to generate electricity in Bangladesh", A5: "Bangladesh government's decision to implement the Rooppur Nuclear Power Plant project was right".

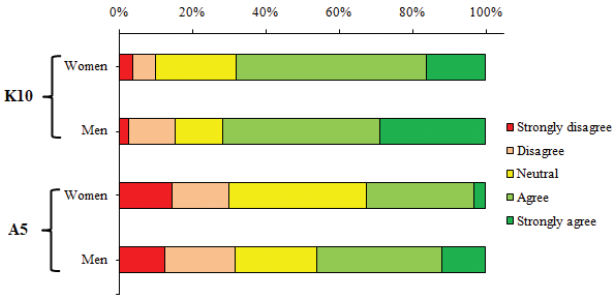

Figure A8. Gender-wise responses to K10 and A5.

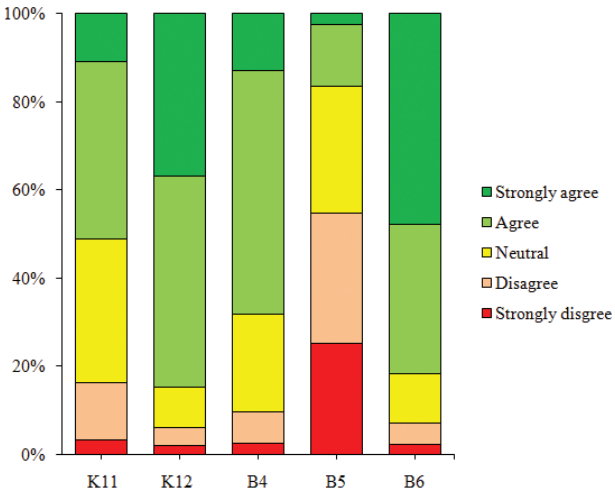

Figure A9. Cumulative responses to K11: "Per unit electricity cost produced by nuclear would be cheaper than coal", K12: "To increase more public support, nuclear education should be added to the secondary and tertiary education level of Bangladesh", B4: "Nuclear power plants can meet present energy crisis in Bangladesh", B5: "Nuclear power plant is safe for Bangladesh", B6: "Nuclear power plant waste is a concern for people and environment".

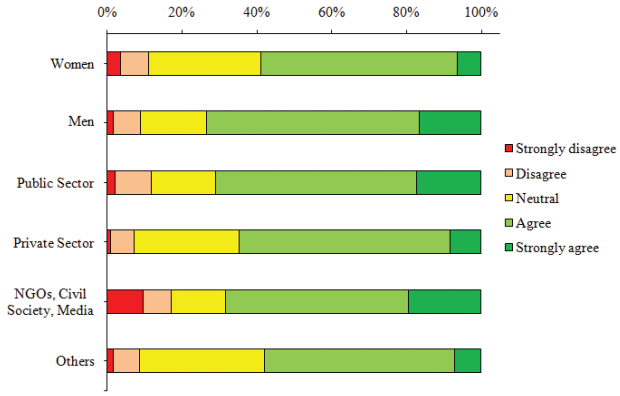

Figure A10. Gender and occupation-wise responses to B4.

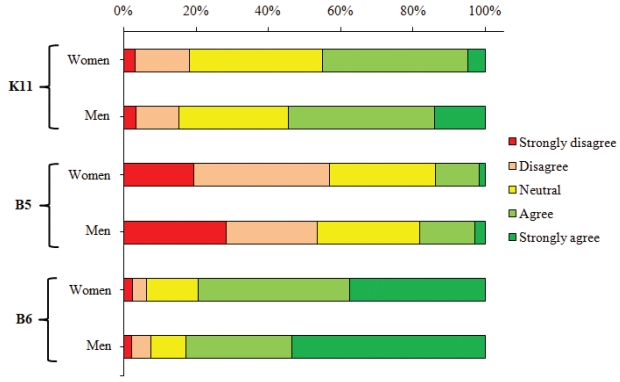

Figure A11. Gender-wise responses to K11, B5 and B6.

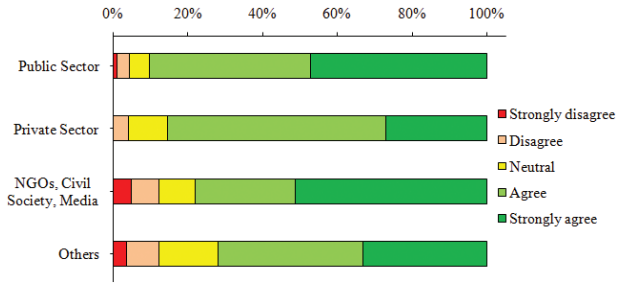

Figure A12. Occupation-wise responses to K12: "To increase more public support, nuclear education should be added to the secondary and tertiary education level of Bangladesh".

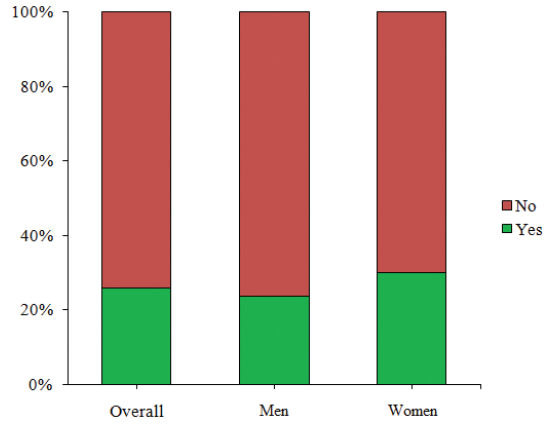

Figure A13. Responses to K13: "Before completion of Rooppur nuclear power plant construction and without gaining operating experiences from it, do you think the Government of Bangladesh (GoB) should go for another construction of a nuclear power plant at other site?".