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From promise to legitimacy: a survey-based study of stakeholder engagement and public acceptance of small modular reactors in the UK

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A B S T R A C T

This study examines the social, institutional, and contextual factors influencing public perceptions of Small Modular Reactors (SMRs) in the United Kingdom, with a focus on how participatory decision-making processes affect site selection for new nuclear developments. In contrast to most existing research centred on conventional large-scale reactors, the study situates SMRs within the UK's distinct regulatory, environmental, and social context, aligning with sustainable energy development within low-carbon transitions. Drawing on household survey data collected near two proposed SMR sites in the UK, the study finds that attitudes toward SMRs are shaped by technical understanding, trust in institutions, perceived safety, proximity to proposed sites, confidence in nuclear waste management, and expected environmental and economic benefits. Persistent concerns remain regarding long-term risks, radioactive waste, and a pronounced "Not-In-My-Backyard" (NIMBY) effect among residents near proposed sites. Analysis of stakeholder engagement practices indicates that transparent, early, and inclusive consultation, supported by accessible information and independent oversight, increases public trust and perceived legitimacy. In contrast, superficial or tokenistic engagement reduces acceptance and heightens opposition. The findings point to the importance of governance innovation and social learning in enabling socially acceptable low-carbon energy transitions, and provide evidence to inform policy, industry practice, and community engagement in the deployment of emerging nuclear technologies.

Introduction

The imperative to address climate change and ensure sustainable energy security has reignited global interest in nuclear power as a vital component of a low-carbon future. Central to this resurgence is the development and deployment of Small Modular Reactors (SMRs), which are increasingly recognised as a transformative advancement in nuclear energy technology. SMRs offer numerous advantages, including scalability, enhanced safety features, cost-effectiveness, and reduced waste production, positioning them as a critical enabler of decarbonisation pathways [1–3]. Their compact design and modular construction facilitate deployment in diverse locations, such as remote areas or existing nuclear sites, while minimising land requirements and environmental disruption [4–6]. As countries seek to transition to low-carbon energy systems, SMRs have emerged as a promising solution that addresses the twin challenges of energy reliability and environmental sustainability.

The United Kingdom (UK) has identified SMRs as a pivotal component of its strategy to achieve net-zero carbon emissions by 2050, a goal enshrined in the Climate Change Act 2008 [7]. UK policymakers have recognised the flexibility and scalability of SMRs, which enable their integration with intermittent renewable energy sources, thereby enhancing the stability and reliability of the national energy grid [8]. By reducing reliance on fossil fuels, supporting energy independence, and fostering domestic manufacturing capacity, SMR deployment has the potential to strengthen the UK's energy security while driving economic growth [9]. Moreover, the smaller physical footprint of SMRs, relative to traditional large-scale reactors, allows for their installation on constrained sites, thereby reducing spatial requirements and limiting adverse environmental impacts [10].

One of the most significant technological advances in SMR design is the inclusion of passive safety features, such as self-regulating cooling systems and containment structures, which substantially mitigate the risk of catastrophic failure [4]. These innovations respond directly to longstanding public concerns about nuclear safety, which have been amplified by historical nuclear accidents, notably the Chernobyl disaster (1986) and the Fukushima Daiichi nuclear disaster [11]. Some SMR

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designs utilise optimised fuel cycles that have the potential to reduce long-lived radioactive waste compared to conventional reactors, though waste profiles vary significantly by design [12]. Collectively, these advancements offer an opportunity to reframe the narrative around nuclear energy, positioning SMRs as a safe, efficient, and sustainable alternative to traditional nuclear reactors [13].

While SMRs share the low-carbon credentials of conventional large-scale reactors (LSGs), the two technologies differ considerably in design, safety architecture, construction model, economics, and regulatory requirements. LSGs benefit from well-established regulatory frameworks, mature active safety systems with decades of operational validation, and economies of scale that lower per-unit costs; SMRs have yet to demonstrate these advantages at commercial scale [14]. SMRs, by contrast, offer modular factory fabrication, passive safety features that reduce operator dependency, shorter construction timelines, lower upfront capital, and greater deployment flexibility, including installation in remote areas or on retiring fossil fuel sites [15,16]. However, SMR per-kilowatt costs remain higher than those of LSGs due to immature supply chains, and regulatory pathways for novel designs are still incomplete in most jurisdictions, including the UK [17,18]. The case for SMRs therefore, rests not on replacing LSGs wholesale but on filling niches where large reactors are not practical. No SMR has yet entered full commercial operation in the UK. In North Wales, Wylfa has been selected as the site for the country's first SMR project, but the reactors are not yet under operation, and first grid connection is still anticipated in the mid-2030 s. The sites examined in this study therefore remain proposed developments rather than active SMR facilities [19].

Beyond the technical differences, the modular and factory-built nature of SMRs may also shift public perception in ways that differ from large reactor projects. Smaller scale, physical containment within a compact unit, and serial production can lower the sense of catastrophic, uncontrollable risk that has historically shaped public fears of nuclear energy [20]. Even so, public scepticism persists, driven by safety concerns, nuclear waste, and broader environmental risks [11]. Public attitudes remain shaped by past accidents, and the NIMBY effect continues to generate opposition near proposed sites [13]. Understanding what drives these perceptions is central to this study.

Stakeholder collaboration is another critical dimension influencing the successful deployment of SMRs. The implementation of SMRs requires a concerted effort from a diverse range of actors, including government agencies, regulatory bodies, private developers, and local communities [21]. Effective collaboration among these stakeholders is essential for ensuring regulatory compliance, fostering community support, and mitigating risks associated with cost overruns and project delays. The UK's nuclear energy strategy emphasises the importance of stakeholder engagement frameworks, which promote transparency, inclusiveness, and accountability throughout the development process [22]. Without effective collaboration, the risk of project failure increases, as evidenced by prior delays in nuclear site development both within the UK and internationally [23]. This study, therefore, assesses the effectiveness of stakeholder collaboration and identifies best practices for engagement in the UK context.

Public acceptance of nuclear technologies is also shaped by trust in institutions. Research shows that confidence in regulators and plant operators increases support for nuclear technologies, as trust reduces uncertainty and lessens perceived risk [24]. Trust is not built through technical performance alone; it develops through transparent decision-making and meaningful stakeholder involvement. Procedural justice research confirms this, showing that people are more likely to view decisions as legitimate when the process is fair and inclusive, even if they disagree with the outcome [25]. Behavioural models add further context: the Theory of Planned Behaviour [26] and the Technology Acceptance Model [27] both suggest that effective engagement shapes attitudes, builds social norms, and gives communities a genuine sense of control over decisions.

At a broader level, social acceptance of energy projects operates across national, community, and market dimensions, and national support does not automatically translate into local acceptance [13,28]. The concept of a Social Licence to Operate highlights that acceptance is earned over time through trust and legitimacy rather than secured through a single formal approval [29]. Energy justice theory adds that legitimacy also depends on whether risks and benefits are distributed fairly and whether marginalised groups are recognised in decision-making [30]. Collaborative governance theory further shows that institutional design, power imbalances, and leadership quality all shape how well participatory processes function in practice [31]. These frameworks collectively inform the analytical approach taken in this study.

Although extensive research has been conducted on public perception and stakeholder collaboration in nuclear energy development, most studies have focused on large-scale reactors. Studies on public perceptions in accident and climate- energy contexts show that the UK public often accepts nuclear power reluctantly. This acceptance is driven more by climate concerns than genuine support [11 32]. Work on the technical and governance dimensions of nuclear development highlights the importance of procedural fairness and meaningful community involvement in securing a social licence to operate [21,23]. However, these studies do not account for the distinct features of small modular reactors, including their smaller footprint, factory-based construction, and evolving regulatory status. They also overlook public attitudes in a pre-deployment context, where no operational SMR facility yet exists.

Existing research also shows a clear geographical bias, with most studies focused on the United States, continental Europe, and East Asia [33]. The UK's distinct regulatory, environmental, and social context cannot be directly compared to these settings. Furthermore, while public perception and stakeholder collaboration have each been studied independently, their combined effect on site selection and community acceptance remains underexplored. This study addresses both gaps by examining these two factors together within the UK's specific pre-deployment context.

This study aims to bridge these knowledge gaps by addressing the following key research questions:

1. What factors influence public perception of SMRs in the UK, and how do they vary across different social, demographic, and geographic contexts?
2. How effective is the collaborative effort among stakeholders in identifying and selecting nuclear sites for SMRs in the UK?

To address these questions, the study formulates the following research hypotheses:

- **H1**: Individuals with greater knowledge of the benefits and risks associated with SMRs will exhibit more favourable perceptions of SMRs compared to those with limited knowledge.
- **H2**: The presence of 'Not-In-My-Backyard' (NIMBY) sentiments will mediate the relationship between proximity to SMR sites (either as factories or operational reactors) and public perceptions, with individuals living closer to SMRs expressing greater opposition compared to those residing farther away.
- **H3**: The effectiveness of collaborative efforts among stakeholders in the identification and selection of nuclear sites positively influences the level of transparency, stakeholder engagement, and the successful establishment of nuclear facilities.

This study makes the following contributions to the field:

(i) It provides new insights into SMR-specific public perception factors, including trust, risk perception, environmental concerns, and economic benefits.

(ii) It identifies best practices for stakeholder engagement, communication, and collaborative decision-making in the context of SMR deployment.
(iii) It proposes an integrated framework examining the relationship between public perception and stakeholder collaboration.
(iv) It informs policy recommendations for UK regulators, industry practitioners, and public engagement initiatives.

The remainder of the paper is structured as follows. Section 2 describes the research design and methodology. Section 3 presents the findings. Section 4 discusses the results in relation to existing literature, and Section 5 concludes with policy implications and directions for future research.

Methodology

Research design

To address the two primary research questions: (1) What factors influence public perception of SMRs in the UK, and how do these factors vary across different social, demographic, and geographic contexts? and (2) How effective is the collaborative effort among stakeholders in identifying and selecting nuclear sites for SMRs in the UK? The study employs an innovative survey research design.

This survey design incorporates advanced sampling techniques, utilising online (including mobile) platforms. This method approach enhances the representativeness of the sample and reduces potential selection bias. A distinctive feature of the survey instrument is the use of dynamic question formats, which engage participants in a three-stage process of questioning before and after exposure to targeted information about SMRs. This design allows for a robust analysis of the causal impact of information awareness on public perceptions of SMRs, an approach not previously applied in studies on this topic. By adopting this innovative survey design, the study identifies causal relationships, controls potential biases, and enhances both replicability and generalisability.

Study setting

Rolls-Royce SMR has been selected by the UK government to develop the country's first SMR, with three units planned for Wylfa in North Wales and first grid connection anticipated in the mid-2030 s [34]. As of mid-2024, Rolls-Royce SMR had identified a total of 10 potential sites for SMR deployment, categorised as follows: two shortlisted sites, four potential sites, and four sites under investigation. To facilitate the proposed research on public perception and stakeholder engagement in SMR deployment, two pilot sites have been selected: Ratcliffe-on-Soar and Oldbury- North. These sites were selected due to their proximity and status as proposed locations for SMR deployment, ensuring the research captures diverse perspectives from two distinct development phases.

The Ratcliffe-on-Soar Power Station is a decommissioned coal-fired power station located in Ratcliffe-on-Soar, Nottinghamshire, England. Following its closure in September 2024, the site has been identified for redevelopment into a zero-carbon technology and energy hub, with the potential for SMR development as part of the UK's broader energy transition strategy. This site's dual role as a former coal-fired power station and a future hub for low-carbon technologies makes it a critical location for studying public perception of SMRs in the context of energy transition and decarbonisation.

The Oldbury Nuclear Site is a decommissioned nuclear facility situated in Oldbury-on-Severn, South Gloucestershire, England. The site was acquired by Great British Nuclear in March 2024 from Hitachi for the development of future nuclear energy projects, including potential deployment of SMRs. The Oldbury site is part of the UK's long-term nuclear strategy and represents an example of a site under investigation for potential SMR deployment, making it a valuable location for exploring stakeholder engagement and public perception of nuclear energy in areas previously associated with nuclear infrastructure.

Both sites present strategic opportunities for data collection on public attitudes towards SMRs and the processes of stakeholder collaboration in site selection and development. By selecting one site from the potential sites list (Ratcliffe-on-Soar) and one from the investigation sites list (Oldbury −North), the research ensures a diverse contextual framework for analysis.

Sampling strategy

The data collection process for this study involves a combination of household surveys. The survey targets households residing within a 1-mile radius of the two selected sites: Ratcliffe-on-Soar and Oldbury − North. Although institutional stakeholders were not directly surveyed in this pilot, the household survey instrument included a dedicated section on stakeholder engagement, covering themes such as public participation, trust and governance, communication and transparency, and social and environmental concerns, including collaborative processes for site identification and selection.

As a pilot study, the results inform the full-scale survey for future research. Although there is no universal consensus on the ideal sample size for pilot studies, the literature suggests that sample sizes can range from 10 to 12 participants per group to as many as 60 to 75 participants per group, depending on the study's objectives and scope [35]. For this study, a sample size of 25 households per group has been deemed appropriate for the pilot phase at the two selected sites. This sample size strikes a balance between feasibility, cost, and the need for adequate data to assess the survey design and methodology. The pilot sample skews toward older residents (49% aged 65 +), which may not fully capture the views of younger communities who will live with the long-term consequences of SMR deployment. This will be addressed through targeted recruitment in the full-scale survey.

Posters are distributed to households in the two selected sites to promote participation in the study. These materials clearly communicate the title and aim of the study, emphasise its focus and significance, and provide essential information on when and how to participate. Additionally, the duration of the survey is specified, and the importance of community participation is highlighted to encourage engagement. To facilitate access, the posters or pamphlets include a QR code and a survey link, enabling participants to complete the survey online. For those unable to participate online, details of a physical location, date, and time are provided, offering an alternative means for participation. The 1-mile radius reflects the immediate host community most directly affected by deployment, consistent with the Detailed Emergency Planning Zones established under the UK's Radiation (Emergency Preparedness and Public Information) Regulations 2019 [36], which typically define immediate host communities within a 1–2 km radius of nuclear facilities [37]. Future research should incorporate wider buffer zones of 1–5 miles and 5–10 miles to examine whether NIMBY sentiment intensifies or dissipates with distance.

Data collection tools and data types

The study employs primary data collection tools where a survey tool collects data on key themes, including public understanding and knowledge, energy policy and economic considerations, environmental and climate change perspectives, risk vs. benefit perception, trust in institutions, sociopolitical and cultural context, ethical and moral concerns, regulatory and legal issues, media framing and communication, demographic and regional variations, and implications for policy and public engagement.

The survey was structured in three stages. Part 1 collected baseline knowledge and attitudes before any information was provided. Part 2 presented participants with a plain-language information sheet titled "An Overview of SMR and Stakeholder Engagement in Nuclear Energy Projects." This material was written specifically for non-technical audiences using short bullet points and simple headings, avoiding technical jargon. It explained what SMRs are, how they differ from conventional large-scale reactors in terms of size, modular construction, passive safety systems, and waste output, and outlined the principles of stakeholder engagement. A frequently asked questions section was also included to address common misconceptions. Part 3 then repeated key perception questions to measure any shift in attitudes following exposure to this information.

Data analysis techniques

This study investigates the factors influencing public perceptions of SMRs and evaluates the effectiveness of collaborative efforts among stakeholders in the identification and selection of suitable nuclear sites in the UK. To achieve these objectives, the study employs a mixed-method approach, incorporating both quantitative and qualitative analysis.

To analyse the factors influencing public perception of SMRs, the study utilized Ordered Probit (OP) model. This model is appropriate due to the ordinal nature of the dependent variable public perception which is measured on a 1–5 Likert scale ranging from Strongly Negative (0), Negative (1), Neutral (2), Positive (3), and Strongly Positive (4). Ordered probit model account for the ordinal nature, underlying thresholds, and non-linear relationships between the dependent and explanatory variables [38,39]. The model assumes that public perception is driven by an underlying latent variable y_i^* that reflects an individual's unobservable attitude towards SMRs. This latent variable is influenced by observed explanatory variables X_i, a set of coefficients β and an error term ε_i that follows a standard normal distribution.

The latent variable is specified as:

$$y_i^* = X_i\beta + \varepsilon_i$$

The observed perception y_i is determined by comparing y_i^* to a set of estimated thresholds $\mu_1, \mu_2, \mu_3 and \mu_4$. The categories of y_i are defined as:

$$y_i = \begin{cases} 0, if y_i^* \leq \mu_1 \\ 1, if \mu_1 < y_i^* \leq \mu_2 \\ 2, if \mu_2 < y_i^* \leq \mu_3 \\ 3 if \mu_3 < y_i^* \leq \mu_4 \\ 4, if y_i^* > \mu_4 \end{cases}$$

The explanatory variables X_i variables (demographic characteristics such as age and education, geographic location relative to SMR sites, environmental concerns, economic interests such as energy costs and job creation, political ideology, science literacy, risk perception, and trust in institutions such as government and industry). Each variable influences y_i^* through its coefficient β where a positive coefficient implies an increase in the likelihood of a higher perception category, while a negative coefficient implies a shift to a lower category.

The probability of observing each perception category j is computed using the cumulative distribution function (CDF) Φ $(\cdot)$ of the normal distribution:

$$P(y_i = |X_i) = \begin{cases} \Phi(\mu_1 - X_i\beta), if j = 0 \\ \Phi(\mu_2 - X_i\beta) - \Phi(\mu_1 - X_i\beta), if j = 1 \\ \Phi(\mu_3 - X_i\beta) - \Phi(\mu_2 - X_i\beta), if j = 2 \\ \Phi(\mu_4 - X_i\beta) - \Phi(\mu_3 - X_i\beta), if j = 3 \\ 1 - \Phi(\mu_4 - X_i\beta), if j = 4 \end{cases}$$

The likelihood function is used to estimate the model parameters (β *and* μ) via maximum likelihood estimation (MLE). The ordered probit model provides critical insights into the factors influencing public support or opposition to SMRs. For example, proximity to an SMR site may reduce public acceptance (NIMBY effect), while stakeholder engagement or trust in government may increase support.

In addition to the ordered probit, the study employs a multinomial model to analyse the factors that influence the support for the development of SMRs. The multinomial choice model is used to analyse respondents' decisions regarding the support for the development of SMRs, with three possible outcomes: Yes (support), No(opposition), Unsure (undecided/neutral). The model equation estimated is as follows:

$$P(Y_i = j) = \frac{\exp(X_i\beta_i)}{1 + \sum_{k=1}^{j=1}\exp(X_i\beta_k)}$$

Where: $P(Y_i = j)$ the probability that respondent i chooses outcome j $(for\, j = (1,2,3)$. X_i is a vector of explanatory variables for respondent i e.g., age, education level, knowledge of SMR, etc. β_i is a vector of coefficients for outcome j estimated via maximum likelihood estimation.

To understand the impact of a unit change in each independent variable (such as age, education level, knowledge of SMR) on the probabilities of different outcomes (in this case, "yes," "no," or "unsure") regarding support for SMR development, the marginal effects are computed.

Ethical considerations

The research adheres to ethical principles to ensure the protection of participants and maintain the integrity of the study. Key ethical considerations include informed consent, voluntary participation, confidentiality, and data protection. Prior to participation in the household survey, participants were provided with clear information about the purpose, objectives, and procedures of the study. Participants were informed of their right to withdraw at any stage without penalty. For the survey, anonymity was maintained, with no personally identifiable information being collected, and responses were stored securely and used solely for research purposes.

Validity and reliability

To ensure validity and reliability in this study, several strategies were employed. The survey tools were designed based on established concepts and insights from relevant literature on public perception of SMRs and stakeholder collaboration in site selection. To enhance content validity, the survey underwent pilot testing with a small group of participants to identify potential issues with question clarity, structure, and relevance. Reliability was supported by using standardized questions and ensuring consistency in the wording of the survey, reducing the likelihood of misinterpretation. Clear procedures for data collection, storage, and analysis were documented to promote transparency and replicability, ensuring the robustness and credibility of the study's findings

Limitations of the research design

A key limitation was the potential for response bias in the household survey, as participants might have provided socially desirable responses rather than their genuine opinions on SMRs. This could distort findings, particularly on sensitive issues such as nuclear energy and site selection. The sample size and geographic scope (limited to households within a mile radius of the two selected sites) might not have fully reflected the views of broader regional or national populations, which limits the generalizability of the findings. Additionally, the reliance on voluntary participation in the survey introduced the risk of self-selection bias, where only those with strong opinions or vested interests might have chosen to participate, skewing the results

Results

This study examines the social factors shaping public perceptions and acceptance of SMRs in the UK, with a particular focus on public engagement in the decision-making process. Drawing on survey data, the analysis explores how people’s backgrounds, experiences, and interactions with communication and participation processes influence their attitudes toward nuclear energy projects. The following sections present findings on respondent characteristics, participation experiences, communication preferences, key concerns, shifts in perception following information exposure, and broader factors affecting overall public opinion on SMRs and stakeholder engagement.

Public participation, communication and priorities in nuclear energy projects

The survey data reveals the following demographics and responses (Fig. 1.). A significant portion of respondents, 49%, are aged 65 or older, with smaller percentages across other age groups. Education levels show that most participants have at least a bachelor's degree (47%), with 22% having some college or vocational training, and 8% holding a high school diploma or equivalent. The majority of respondents, 90%, have heard of SMRs, with a mixed understanding of the concept 57% know “some” about it, while 6% claim to know “a lot,” and 27% know “a

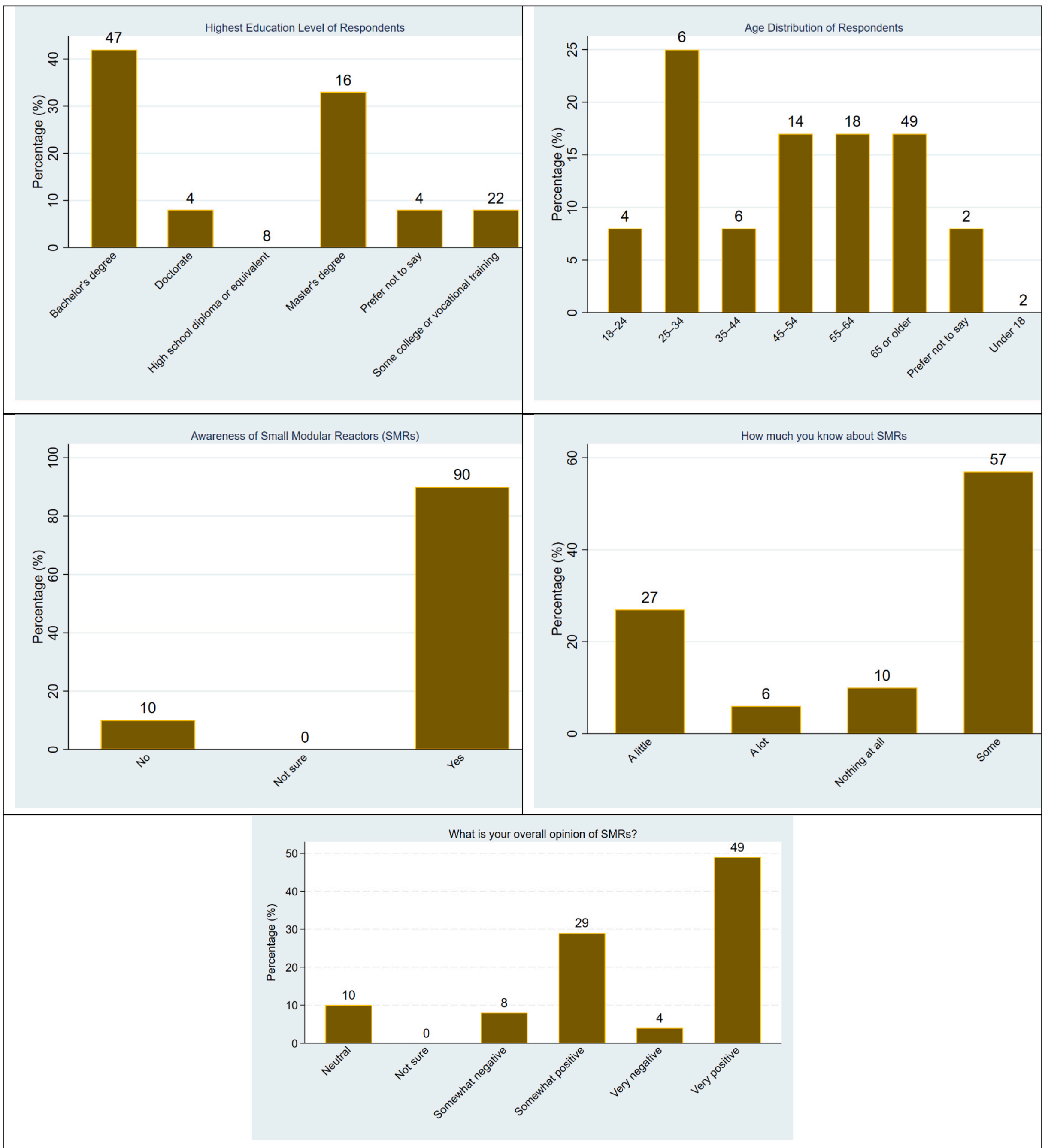

Fig. 1. Demographic Profile of Survey Respondents – (a) highest education levels of respondents; (b) age of the respondents; (c)awareness of SMRs; (d); how much you know about SMRs; and (e) overall opinion of SMRs.

little." Only 10% of respondents report knowing nothing about SMRs. Additionally, a small percentage of participants prefer not to disclose their age, education level, or knowledge of SMRs. The initial opinions on SMRs reveal that 43% of respondents have a very positive view, 33% are somewhat positive, 11% are neutral, 11% are somewhat negative, and 2% are very negative.

Initial public opinions of SMR

Based on the initial opinions of SMRs, ordered probit regression was estimated to examine the factors influencing public perceptions of SMRs. The aim was to identify key variables that shape opinions on SMRs, considering the potential benefits, risks, concerns, as well as factors such as education, level of awareness, and other relevant variables. The results of ordered probit egression are presented in Table 1..

The ordered probit regression results reveal key factors influencing public opinions on SMRs, with opinions measured on an ordinal scale from 1 (most negative) to 5 (most positive).

Education significantly influences opinions, with a positive coefficient of 0.517, indicating that individuals with higher education levels are more likely to view SMRs favourably. Individuals with higher levels of education are more likely to support SMRs, likely due to increased understanding and openness to complex or emerging technologies. This implies that education plays a key role in shaping more informed and positive attitudes toward innovations like SMRs. Knowledge about SMRs also plays a crucial role, as evidenced by a strong positive coefficient of 2.173, meaning that greater knowledge correlates with more favourable opinions. This underscores the role of awareness and information in shaping public acceptance.

Perceived safety is another key factor. With a coefficient of 1.568, individuals who view SMRs as safer are more inclined to have a positive opinion. This supports the idea that emphasising SMRs' inherent safety features can help mitigate concerns about nuclear energy. Conversely, concerns about waste management negatively impact opinions, as indicated by a coefficient of −3.632. This suggests that fears about nuclear waste disposal remain a significant barrier even in the context of newer nuclear technologies.

The perceived risk of accidents also negatively affects opinions, with a coefficient of −2.428, highlighting that safety concerns about nuclear accidents are a persistent challenge. In contrast, perceived security threats (e.g., terrorism) positively influence opinions, as reflected by a coefficient of 2.726. This suggests that the resilience of SMRs to external threats could be a key selling point.

Additionally, the novelty of SMRs is viewed positively by some individuals, as reflected by a coefficient of 1.579 for the variable risk of unproven technology. This suggests that certain individuals see the technology's newness as an opportunity for innovation with potential benefits rather than risk. Perceived regulatory frameworks also positively influence opinions, with a coefficient of 2.144, possibly reflecting confidence in institutional oversight or the belief that effective regulation and scrutiny add legitimacy to SMR development.

Acceptance of proximity to an SMR facility has a positive and statistically significant effect (0.681), suggesting that individuals who are more comfortable with the idea of living near an SMR are also more likely to support the technology overall. In contrast, perceived modularity of construction shows a negative and significant relationship (coefficient = −1.7000) indicating that those who are aware of or focused on the modular construction aspect may hold greater scepticism perhaps due to concerns about experimental design, safety, or unfamiliarity with new reactor formats. Finally, the perception that SMRs offer advantages over traditional nuclear reactors has a strong positive and highly significant effect (coefficient = 2.001), underscoring that highlighting comparative benefits such as efficiency, flexibility, or safety improvements can play a substantial role in gaining public support. Together, these results emphasise the importance of both proximity attitudes and perceived technological benefits in shaping acceptance, while also cautioning that technical design features like modularity may require clearer public communication to mitigate uncertainty.

Given the pilot sample size (N = 50), the ordered probit model provides indicative rather than definitive insights. The model shows a good fit (pseudo R^2 = 0.6075; log pseudolikelihood = –23.35), suggesting it captures meaningful patterns in the data. Results should, however, be interpreted with appropriate caution, and will be further examined in the full study with a larger sample.

Initial drivers for SMR development

When respondents were asked if they support the development and use of SMRs in the UK, 69% of respondents answered yes, 8% said no, and 24% were unsure. A multinomial analysis was carried out to examine the factors influencing support for the development of SMRs, with the aim of identifying the key variables that shape public opinion and levels of support. The result of the multinomial regression estimation is presented in Table 2, and its corresponding marginal effects estimation is presented in Table 3.

Table 1
Ordered probit regression results- factors influencing public perception of SMRs (N = 50).

Variable	Coefficient	Standard Error
Education	0.517*	0.245
Knowledge about SMRs	2.173***	0.501
Acceptance of Proximity to SMR Facility	0.681*	0.313
Perceived Risk of Accidents	−2.428**	0.816
Perceived Security Threats	2.726**	0.961
Perceived Unproven Technology	1.579**	0.522
Perceived Regulatory Challenges	2.144***	0.563
Perceived Safety Features	1.568*	0.725
Perceived Waste Management	−3.632***	0.86
Perceived Modularity Construction	−1.700*	0.858
Perceived SMRs Offer Advantages Over Traditional Nuclear Reactors	2.001***	0.482
Cut-off 1	8.766**	2.675
Cut-off 2	12.16***	2.786
Cut-off 3	14.21***	2.951
Cut-off 4	16.52***	3.217

* p < 0.10, * *p < 0.05, *** p < 0.01.
Source (Author, 2025).

Table 2
Multinomial logit regression results- factors influencing support, opposition, and uncertainty toward SMR development (N = 50).

Variable	Category 2 (No) Coefficient	Standard Error	Category 3 (Unsure) Coefficient	Standard Error
Education	6.660**	0.55	1.123+	0.575
Heard of SMRs	−34.743**	5.016	−1.001	1.712
Perceived Environmental Benefits	31.665**	2.006	1.067	0.967
Perceived Modular Construction Benefits	−29.346**	1.461	−4.556**	1.412
Perceived Risk of Accidents	−20.062**	2.896	2.081	1.463
Perceived Risk of Nuclear Disposal	5.943**	1.538	−0.714	1.52
Perceived Security Threats	3.057	2.649	−0.717	1.28
Perceived Unproven Technology	6.305**	2.051	−0.221	1.226
Perceived Regulatory Challenges	−7.474**	2.043	0.431	0.802
Perceived Acceptance of SMR Proximity	27.845**	1.427	−0.237	0.475

*+ p < 0.10, * p < 0.05, ** p < 0.01.*
Source (Author, 2025).

Table 3
Marginal effects from the multinomial logit model- probability changes in support, opposition, and uncertainty toward SMR development.

Variable	Outcome 1 (Yes, Support) Coefficient	Std. Err.	Outcome 2 (No, Opposition) Coefficient	Std. Err.	Outcome 3 (Unsure, Uncertain) Coefficient	Std. Err.
Education	−0.106*	0.052	2.68e-08**	1.07e-08	0.106*	0.052
Heard of SMRs	0.094	0.163	0.000*	6.36e-08	−0.094	0.163
Perceived Environmental Benefits	−0.101	0.098	1.31e-07**	5.23e-08	0.101	0.098
Perceived Modular Construction Benefits	0.430**	0.127	0.000*	4.84e-08	−0.430**	0.127
Perceived Risk of Accidents	−0.196+	0.116	0.000*	3.66e-08	0.196+	0.116
Perceived Risk of Nuclear Disposal	0.067	0.143	2.55e-08*	1.11e-08	−0.067	0.143
Perceived Security Threats	0.068	0.115	1.34e-08	1.2e-08	−0.068	0.115
Perceived Unproven Technology	0.021	0.116	2.65e-08*	1.28e-08	−0.021	0.116
Perceived Regulatory Challenges	−0.041	0.080	0.000+	1.66e-08	0.041	0.080
Perceived Acceptance of SMR Proximity	0.022	0.080	1.16e-07*	4.77e-08	−0.022	0.046

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.
Source (Author, 2025).

Factors influencing SMR development: multinomial logit analysis

The results of the multinomial logistic regression model (Table 2) offer valuable insights into the factors influencing support for the development of SMRs, with support for SMRs as the dependent variable. The base category in the dependent variable represents the “Yes” responses, while categories 2 and 3 capture the “No” and “Unsure” responses, respectively. Thus, the results for “No” and “Unsure” indicate how various predictors increase or decrease the likelihood of selecting those responses over supporting SMRs. The model fit statistics indicate that the model is highly statistically significant, with a Wald chi2(20) of 2825.76 and a p-value of 0.0000, suggesting that at least one of the independent variables is associated with support for SMRs. The pseudo R2 of 0.5945 indicates that approximately 59.45% of the variation in support for SMRs is explained by the included predictors.

Category 2: “No” vs. “Yes”

Education has a positive and significant effect (coefficient = +6.660), indicating that more highly educated individuals are more likely to oppose SMR development compared to supporting it. This result is unexpected and may reflect greater scrutiny or concern among educated respondents. Having heard of SMRs has a negative and highly significant effect (coefficient = − 34.743), suggesting that individuals who are aware of SMRs are far less likely to oppose them. This underscores the importance of public awareness and information in fostering support.

Perceived environmental benefits show a positive and significant effect (coefficient = +31.665), which is unexpected. Perceived environmental benefits may increase opposition to SMRs when they are outweighed by local safety concerns, distrust, or scepticism toward green claims. Perceived benefits of modular construction have a negative and significant effect (coefficient = − 29.346), meaning that those who see value in modular construction are much less likely to oppose SMRs. This suggests that emphasising construction benefits can be an effective strategy in gaining support.

The perceived risk of accidents has a negative and significant effect (coefficient = − 20.062), which is counterintuitive, as greater perceived risk would typically increase opposition. This may indicate that individuals who acknowledge risks also recognise broader benefits or trust safety measures, reducing their overall opposition. Conversely, the perceived risk of nuclear waste disposal shows a positive and significant association with opposition (coefficient = +5.943), indicating that concerns about long-term waste management increase the likelihood of opposing SMRs.

Perceiving the technology as unproven has a positive and significant effect (coefficient = +6.305), which aligns with expectations: concerns about the maturity and reliability of SMRs raise opposition. Perceived regulatory challenges show a negative and significant effect (coefficient = − 7.474). Surprisingly, this suggests that those who recognise regulatory hurdles are less likely to oppose SMRs, possibly implying that such individuals trust the regulatory process or see these challenges as manageable. Finally, willingness to accept an SMR near one’s home (proximity acceptance) has a negative and highly significant effect (coefficient = − 27.845, $p < 0.01$), indicating that those comfortable with local deployment are strongly inclined to support SMRs.

Category 3: “Unsure” vs. “Yes”

Most variables were established to be insignificant except for education and perceived modular construction benefits. For those who are unsure, education has a positive and marginally significant effect (coefficient = +1.123), suggesting that higher education slightly increases indecision rather than outright opposition. Perceived modular construction benefits have a negative and significant effect (coefficient = − 4.556), meaning that individuals who value modular construction are less likely to be unsure, and more likely to support SMRs.

Marginal effects of factors influencing SMR development

Marginal effect estimation identifies several significant variables influencing support, opposition, and uncertainty regarding SMRs (table 3). The dependent variable has three outcomes: 1 − Yes (support), 2 − No (opposition), and 3 − Unsure (uncertain). The results indicate that education and knowledge of SMRs are the most significant predictors, while other factors such as perceived benefits and risk perceptions do not show meaningful effects.

Education emerges as a complex and somewhat paradoxical factor in shaping attitudes toward SMRs. The results indicate that higher levels of education are significantly associated with both reduced support and increased uncertainty. Specifically, education has a negative marginal effect on support (coefficient = -0.106) and a positive effect of equal magnitude on uncertainty (coefficient = 0.106). While this may initially seem contradictory, it suggests that educated individuals are not necessarily opposed to SMRs but may adopt a more critical or cautious stance. They are more likely to withhold support until they feel they have sufficient information, thereby exhibiting greater uncertainty rather than outright opposition. This pattern implies that educational attainment may correlate with a demand for more nuanced, evidence-based assessments of new technologies, including SMRs.

Heard of SMRs that is, simple awareness of the technology has no significant effect on support or uncertainty but does have a statistically significant, though marginal, positive effect on opposition (coefficient = 0.000). This finding is striking in its implication: mere exposure to the concept of SMRs does not meaningfully sway public opinion in any direction. This reinforces the idea that public attitudes are shaped less by awareness and more by the framing and content of the information received. Simply informing people about SMRs is insufficient; deeper engagement with perceived benefits and risks is essential to influencing support or reducing uncertainty.

Perceived Environmental Benefits adds a unique dimension. Although this factor does not significantly influence support, it has a statistically significant and positive marginal effect on opposition (coefficient = 1.31e-07). This counterintuitive result may suggest that some respondents who acknowledge environmental benefits are still inclined toward opposition perhaps due to overriding concerns about risks or distrust in implementation. Alternatively, it might reflect a latent belief that the environmental benefits are overstated or not enough to outweigh other perceived downsides. Despite not directly boosting support, these finding hints that merely presenting SMRs as environmentally friendly may not be sufficient to win public approval if other concerns, such as safety and waste, remain unresolved.

Perceived Modular Construction Benefits are by far the most influential positive driver of support and clarity of opinion regarding SMRs. The effect is both statistically significant and substantively large: a marginal effect of 0.430 on support and an equally large negative effect on uncertainty (coefficient = -0.430). This indicates that individuals who believe modular construction is beneficial are not only more likely to support SMRs but are also much less likely to remain undecided. The modular construction narrative likely appeals to values such as innovation, cost-efficiency, and scalability, which resonate strongly with those open to technological advancement. This result underscores the importance of emphasizing tangible, design-based advantages when communicating about SMRs to the public. It also suggests that messaging that highlights modular benefits could help reduce indecision and mobilize support.

Perceived Risk of Accidents acts as a deterrent to support and a contributor to uncertainty. The marginal effect on support is negative and marginally significant (coefficient = -0.196), while the same variable has a positive marginal effect on uncertainty (coefficient = 0.196). Although not the strongest predictor in the model, the symmetry of its effects on support and uncertainty implies that accident-related concerns not only decrease enthusiasm but also increase hesitation. This reflects well-documented public fears about nuclear safety, particularly considering historical events like Chernobyl and Fukushima. It suggests that individuals concerned about potential accidents are not necessarily firmly opposed to SMRs, but may remain uncertain until reassured by safety protocols, regulatory oversight, or technological improvements.

Perceived Risk of Nuclear Waste Disposal shows a more nuanced but notable effect, primarily on opposition. The marginal effect on opposition is statistically significant though small (coefficient = 2.55e-08), indicating that even minimal increases in perceived waste-related risks can push individuals slightly toward opposition.

Perceived Unproven Technology is associated with slightly increased opposition (coefficient = 2.65e-08), reflecting the public's wariness toward new or untested innovations. Although the effect is statistically significant, it is very small, suggesting that while this perception does move attitudes slightly, it is not a dominant concern compared to modular benefits or accident risks.

The positive and marginally significant effect of perceived regulatory challenges on opposition, despite its extremely small coefficient (coefficient = 0.000,), suggests a statistically detectable but practically negligible relationship. This indicates that individuals who view SMR development as entangled in regulatory difficulties may be slightly more inclined to oppose it, potentially reflecting broader scepticism toward institutional capacity, governance, or the feasibility of deployment. However, the minute effect size implies that such perceptions likely do not drive opposition directly but may instead reinforce existing concerns or contribute to a more general negative outlook.

For Perceived Regulatory Challenges, the results show there is a very small but statistically significant positive effect on opposition. This implies that individuals who perceive greater regulatory obstacles are marginally more inclined to oppose SMRs, even if the effect size is minimal.

In contrast, perceived acceptance of SMR proximity shows a positive and statistically significant effect on opposition (coefficient = 1.16e-07), though the effect size is very small. This implies that as individuals perceive greater public acceptance of living near an SMR, opposition slightly increases, which is counterintuitive. This may reflect underlying disbelief where people question the sincerity or realism of perceived acceptance, or it could signal tension between social norms and personal preferences.

When asked if they have ever participated in public consultations or meetings related to nuclear energy projects, 22% of respondents answered yes, while 78% answered no (Fig. 2. –first graph titled "public participation in nuclear energy consultations). Among those who participated, 9% rated their experience as very positive, 45% as positive, 18% as neutral, 18% as negative, and 9% as very negative (Fig. 2. – second graph titled "perception of public participation in nuclear energy consultations").

The survey results reveal a mixed view on public involvement and transparency in nuclear energy projects. When asked if their opinions are considered in decision-making, nearly half of the respondents (48%) remained neutral, with 30% expressing disagreement and only 12% agreeing (Fig. 3.–the first graph titled "do public opinions matter in nuclear projects decision-making"). Opportunities for public participation in nuclear projects also drew a lukewarm response, as 48% felt indifferent, 28% disagreed, and just 16% agreed (Fig. 3.- second graph title "opportunities for public participation in nuclear projects).

When it comes to addressing community concerns through stakeholder engagement, the majority (46%) were neutral, but 22% saw some effectiveness, while 18% disagreed (Fig. 4. – first figure titled "Effective stakeholder engagement for community concerns.". Interestingly, when asked about the collaborative efforts in selecting nuclear sites, a stronger sense of optimism emerged, with 38% agreeing and 18% strongly agreeing that these efforts help improve transparency and trust (Fig. 4. –the middle graph titled "agreement with collaborative efforts in nuclear selection").

Respondents were asked to identify the factors that most influence their trust in nuclear energy projects. The majority, 82%, selected safety measures and regulations as the primary factor. Other significant influences included environmental impact (49%), transparency in communication (41%), and community involvement (37%). Economic benefits, such as job creation, were cited by 33%, while 29% mentioned past nuclear accidents. Additionally, 10% identified media coverage, and 6% pointed to other factors (Fig. 4.-last graph titled "drivers of public trust in nuclear energy".

Among those who selected "other factors," several key points emerged. Government oversight was frequently highlighted as a critical factor for large-scale energy projects, particularly nuclear, with many respondents expressing concerns that commercial operators might prioritise short-term goals over long-term consequences. While some participants expressed trust in the technology and regulatory framework based on their personal experiences, others raised concerns about the cost and inefficiencies of modular construction, the shortage of skilled labour, and the potential for the private sector to shift risks onto taxpayers.

When it comes to staying informed about nuclear energy projects (Fig. 5.-the first graph titled 'effective methods of communication for nuclear energy'), respondents favoured official websites (75%), public meetings and town halls (71%), and community newsletters (67%) as the most effective communication methods. News media (53%) and direct mailings (53%) also received significant support, while social media platforms (25%) and educational workshops (27%) were less favoured. Some respondents who selected "Other" indicated a preference for independent YouTube channels, such as 'Just Have a Think' and 'Sabine Hossenfelder,' for obtaining information. They noted that public meetings are often disorganised and unproductive, while social media is viewed as unreliable. Additionally, they expressed concerns that community newsletters and information from developers tend to be overly positive and biased. A few respondents highlighted media outlets like Channel 4 News and The Guardian as providing higher-quality coverage, while most other sources were considered to lack reliability.

Regarding satisfaction with the current level of communication from nuclear energy project developers and regulators, 25% of respondents were satisfied, 37% were neutral, 35% were dissatisfied, and 2% were

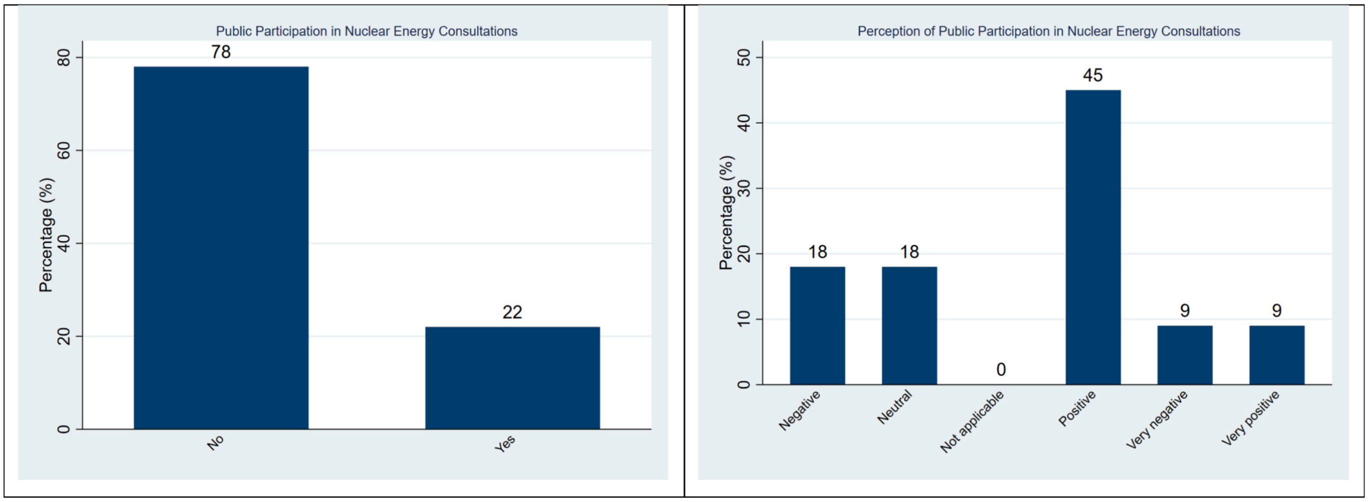

Fig. 2. (a) Public participation in nuclear energy consultations; (b) Perception of public participation in nuclear energy consultations.

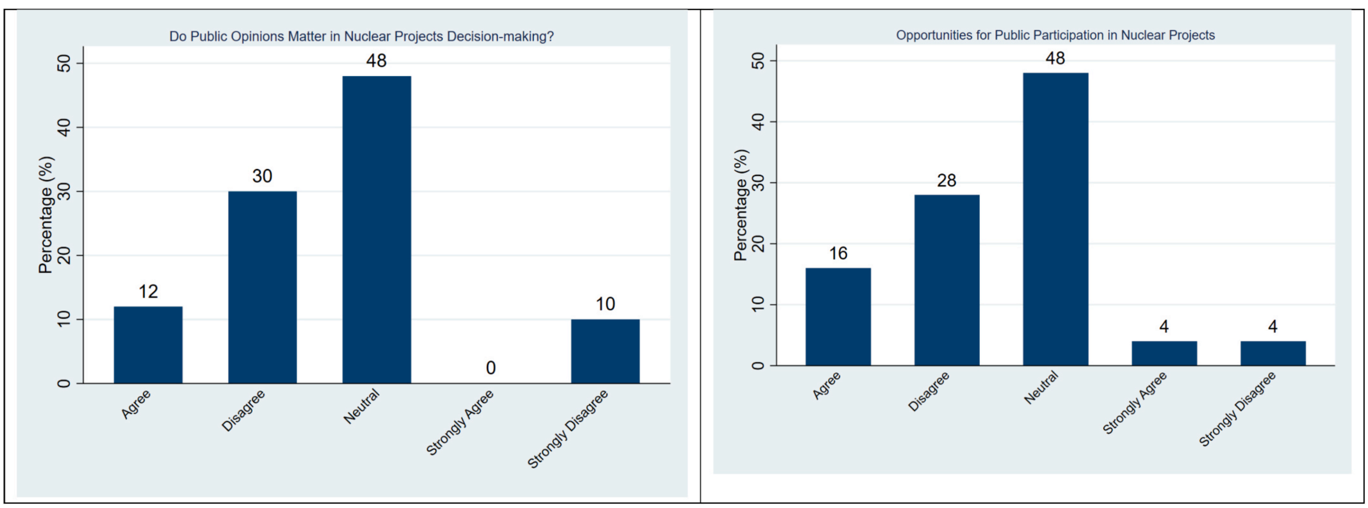

Fig. 3. (a) Public views on whether opinions are considered in nuclear decision-making; (b) Perceived opportunities for public participation in nuclear projects.

very dissatisfied (Fig. 5. –the middle graph titled 'satisfaction with communication from project stakeholders').

In terms of areas for improvement in communication, respondents identified several key areas. The frequency of updates (53%) and the clarity of information (49%) were the top priorities, followed closely by transparency about risks (47%) and accessibility of information (51%). Additionally, 47% of respondents emphasized the need for better use of multiple communication channels, while 31% highlighted the importance of being more responsive to public inquiries. Among those who selected "Other," some respondents noted the insufficient inclusion of technical and financial data in the information provided. They also observed that the UK nuclear industry has been ineffective in engaging with the public and adequately communicating the benefits of the technology (Fig. 5- the last graph titled 'Areas of communication that could be improved'.

When ranking factors in the decision-making process of nuclear energy projects, safety and risk management stood out as the most important consideration, with 80% of respondents selecting it as their top priority. Environmental impact and transparency/accountability followed, each being ranked first by 35% of respondents (Fig. 6). Economic benefits were identified as the most important factor by 24%, while community involvement, though somewhat lower, was still prioritised first by 16% of respondents. These percentages reflect only the proportion of respondents who ranked each factor as their number one priority.

Regarding environmental concerns, 22% of respondents expressed being very concerned about the environmental impacts of nuclear energy projects, and 37% were somewhat concerned (Fig. 7. – first graph titled "concern about environmental impacts of nuclear energy". When asked if nuclear energy projects adequately address social impacts on local communities, 49% were unsure, while 29% believed they did, and 22% disagreed (Fig. 7.: middle graph titles "do nuclear projects account for local social concerns?"). In terms of environmental or social impacts, nuclear waste disposal was the most significant concern, selected by 82% of respondents, followed by ecosystem disruption (44%) and radiation exposure (38%). Other concerns mentioned included health effects on communities (38%) and displacement of residents (23%). Some respondents (other, 8%) also noted concerns regarding environmental mitigation, such as the impact of cooling water intakes on fish stock, and issues related to traffic (Fig. 7.- last graph titled "top environmental and social concerns".

Shifts in attitudes and knowledge after information exposure

The results of the shift in attitudes and knowledge after information exposure is presented in Fig. 8.. Before reading the information on SMRs

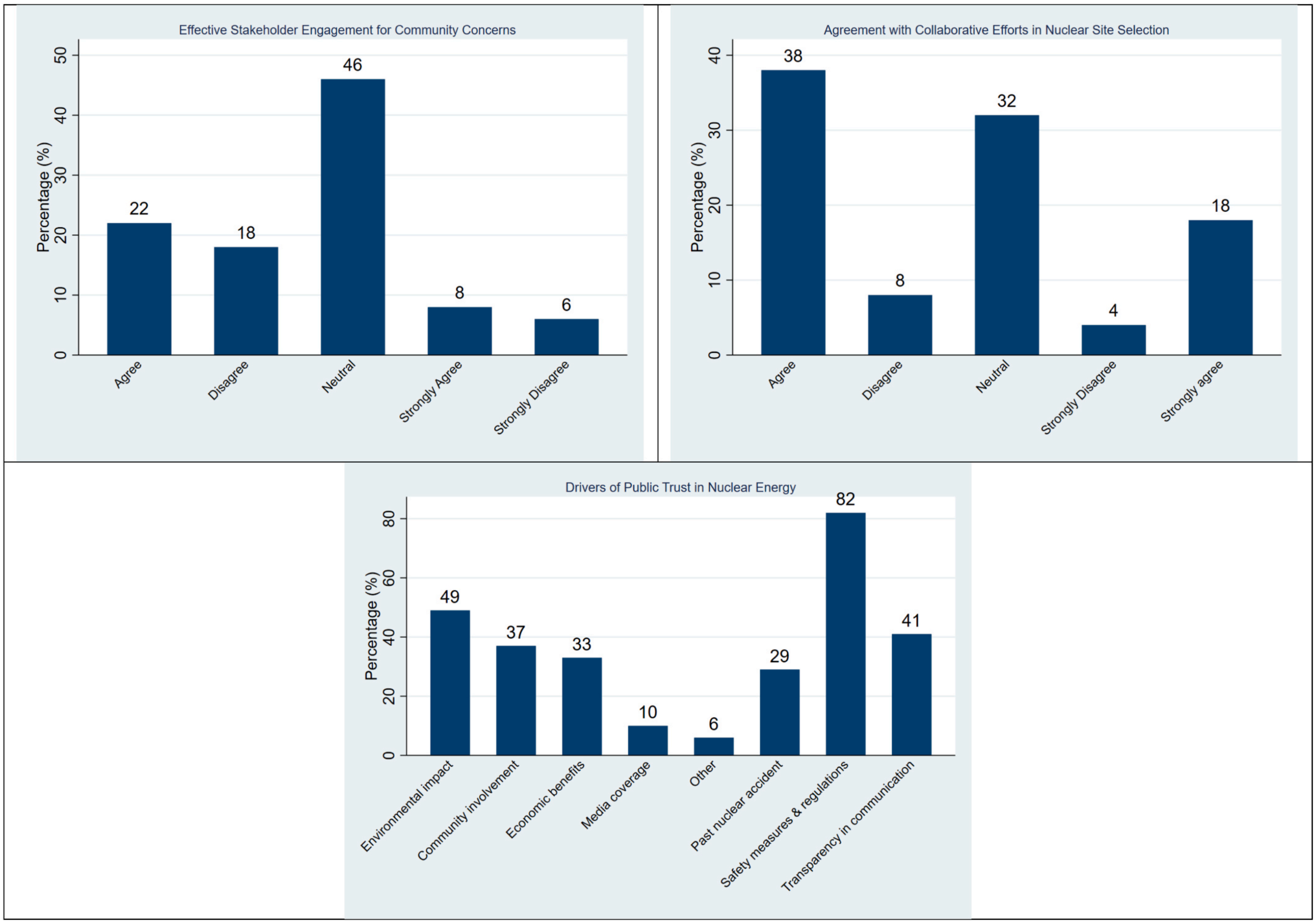

Fig. 4. (a) Perceived effectiveness of stakeholder engagement in addressing community concerns; (b) Agreement with collaborative efforts in nuclear site selection; (c) Drivers of public trust in nuclear energy projects.

and stakeholder engagement, respondents had a mixed level of knowledge. While 57% reported knowing "some" about SMRs, only 6% claimed to know "a lot," and 10% knew "nothing at all." After reading the material, the percentage of those who knew "a lot" increased to 16%, and those who knew "some" rose to 69% Fig. 9..

Concerns about SMRs showed noticeable changes. Before reading the material, the top concerns included lack of public knowledge (61%), nuclear waste disposal (59%), and security threats (51%). After reading, concerns about nuclear waste disposal remained high at 62%, but concerns about public knowledge (44%) and security threats (44%) decreased. The concern about unproven technology remained fairly stable at 26%. Respondents' trust in the government's ability to manage nuclear energy projects safely improved slightly, with 46% agreeing after reading the material compared to 38% before.

Similarly, agreement that nuclear energy projects are transparent in their operations increased from 30% to 36%. Before reading, 38% of respondents strongly agreed that SMRs offer significant advantages over traditional nuclear reactors, which increased to 48% after reading. Further, when asked if collaborative efforts in selecting nuclear sites improve transparency and trust, there was a notable shift, with 34% strongly agreeing after reading, up from 18% before.

Additionally, comfort with having an SMR facility near their community also saw a slight increase, from 38% strongly agreeing before to 42% after. When asked about the safety of SMRs, the responses remained largely unchanged, with 74% initially agreeing that SMRs are safe, and 73% agreeing after reading the material.

Regarding opinions on SMRs, there was a slight shift after reading the material. Initially, 43% of respondents had a "very positive" view, and 33% had a "somewhat positive" opinion. After reading, those with a "very positive" opinion increased to 49%, while "somewhat positive" opinions dropped to 29%. Neutral and negative opinions also decreased slightly.

Support for the development and use of SMRs also saw a slight increase, from 69% in favour before reading to 73% after reading the material, while the percentage of respondents unsure about supporting SMRs decreased.

Factors influencing overall opinions on nuclear energy, SMRs, and stakeholder engagement

In response to the question, "Has the information you read changed your opinion about nuclear energy, SMRs, or stakeholder engagement?", 61% of respondents reported no change in their opinion. 31% felt more positive about these topics, while 4% felt more negative, and another 4% were unsure. This suggests that the majority of individuals did not alter their views after reading the information, though a smaller portion became more positive, and very few felt more negative or uncertain.

A multinomial logit model was then estimated to understand the factors influencing opinions on nuclear energy, SMRs, and stakeholder engagement. The analysis aimed to examine how various predictors influenced the probability of changes in opinion across four categories: Yes, I feel more positive; yes, I feel more negative; No change; and not sure. The model used marginal effects to assess the impact of each predictor on these outcomes, with p-values indicating the statistical

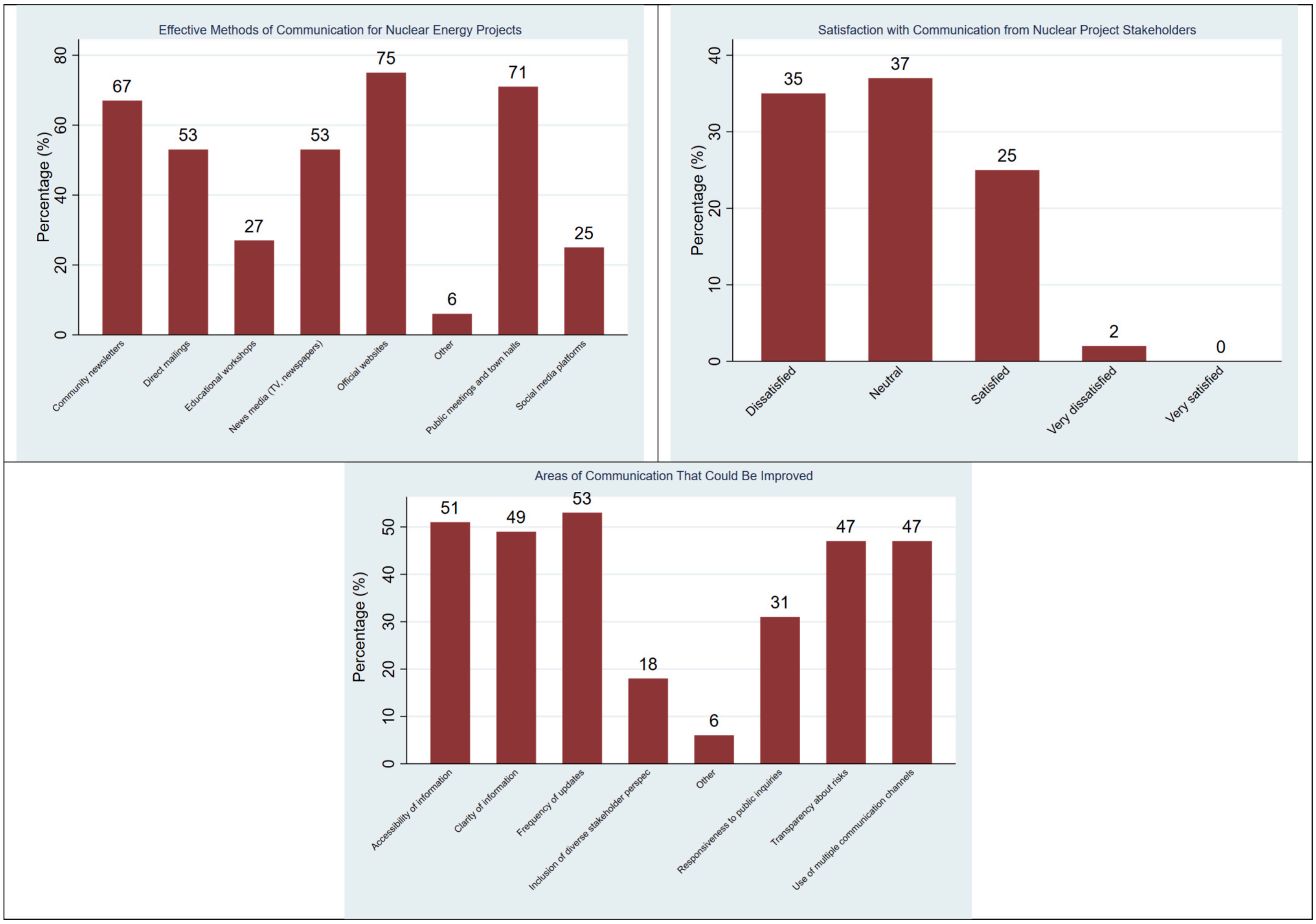

Fig. 5. (a) Effective methods of communication for nuclear energy projects; (b) Satisfaction with communication from stakeholders; (c) Areas identified for improvement in nuclear energy communication.

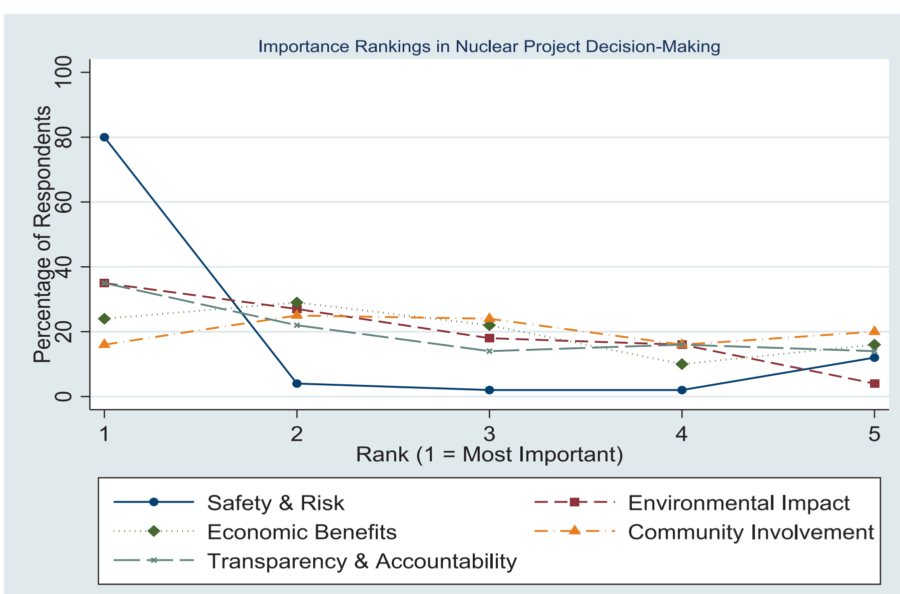

Fig. 6. Public ranking of key decision factors in nuclear energy projects.

significance of each effect. The results are presented in Table 4. and Fig. 3.

As shown in Table 4, the belief that SMRs enhance safety had a marginally significant effect in reducing negative sentiment (coefficient

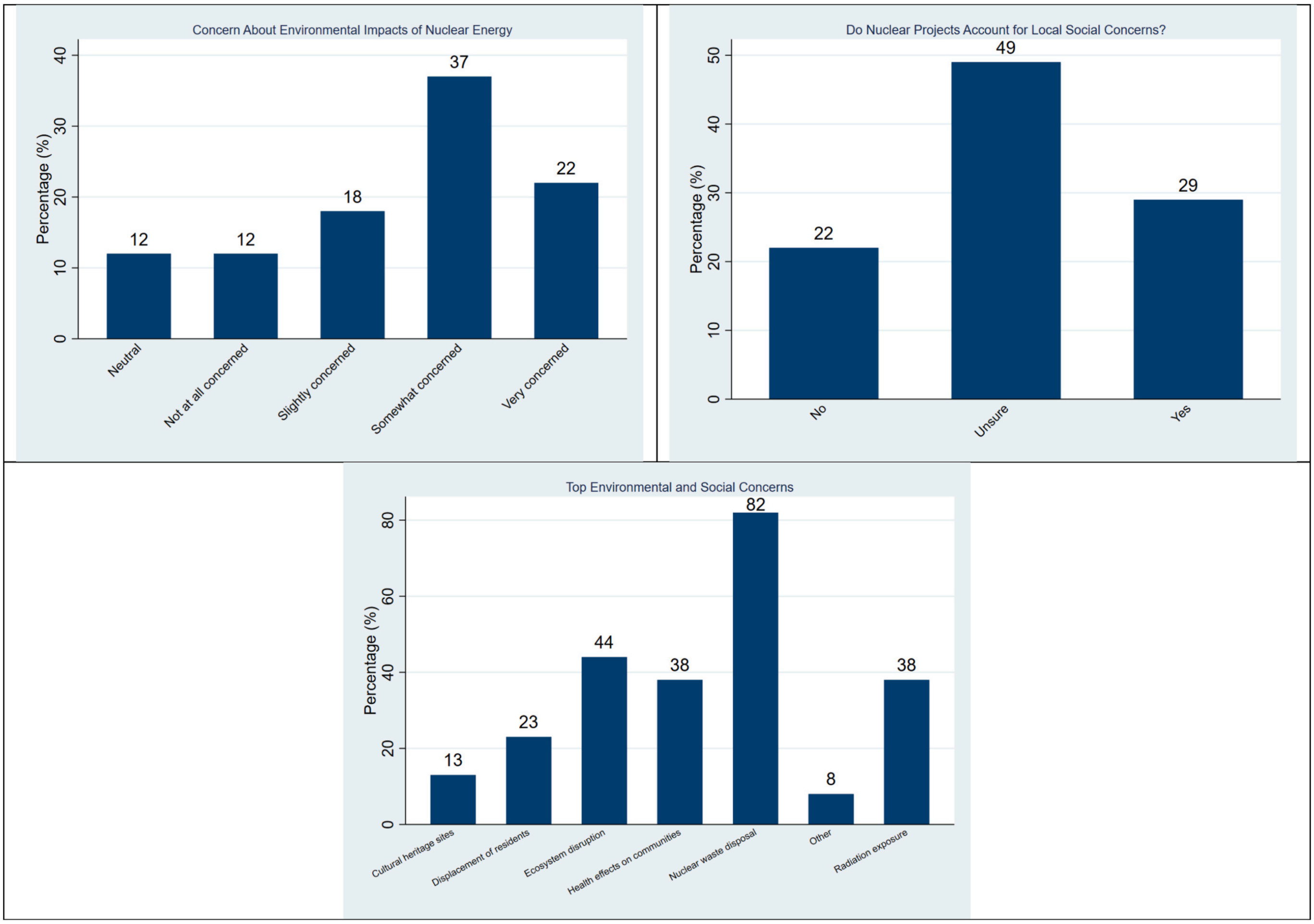

Fig. 7. (a) Level of concern about environmental impacts of nuclear energy; (b) Views on whether nuclear projects adequately address local social concerns; (c) Top environmental and social concerns identified by respondents.

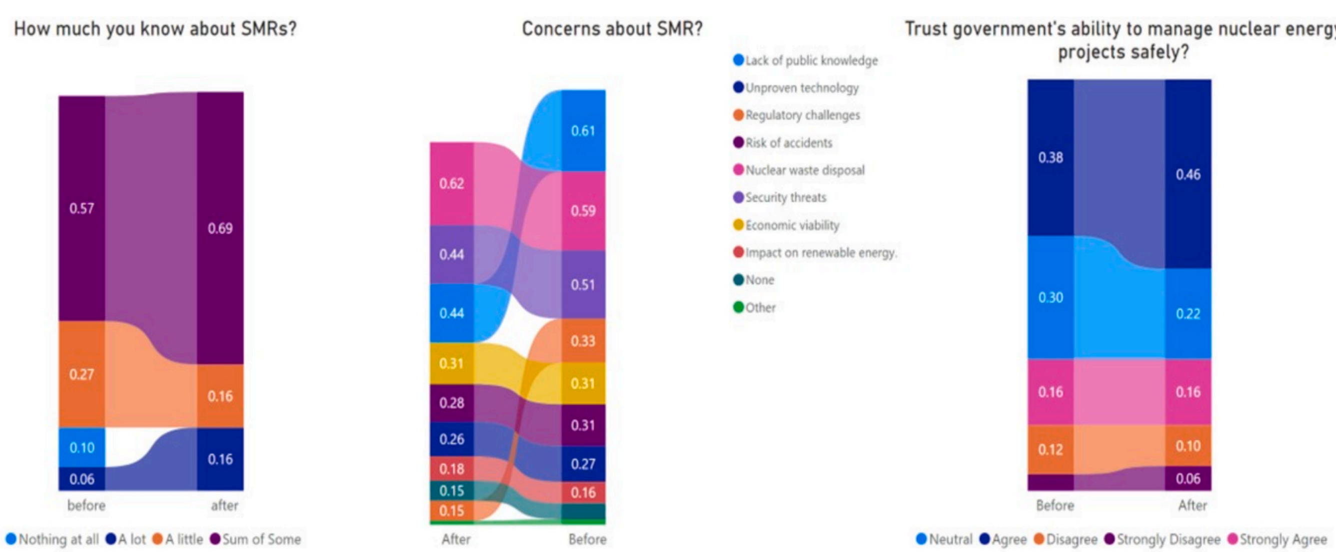

Fig. 8. Shifts in self-reported knowledge about SMRs before and after reading the information material.

–0.589) and increased the probability of respondents selecting “No change” (coefficient = 0.657).

Framing SMRs around economic benefits had a statistically significant negative effect on support (coefficient = –0.437), and a strong positive effect on neutrality (coefficient = 1.213) as presented in table 4. These results suggest that economic messaging may fail to persuade, and instead encourages respondents to remain neutral, possibly due to scepticism or perceived irrelevance of economic claims to safety or

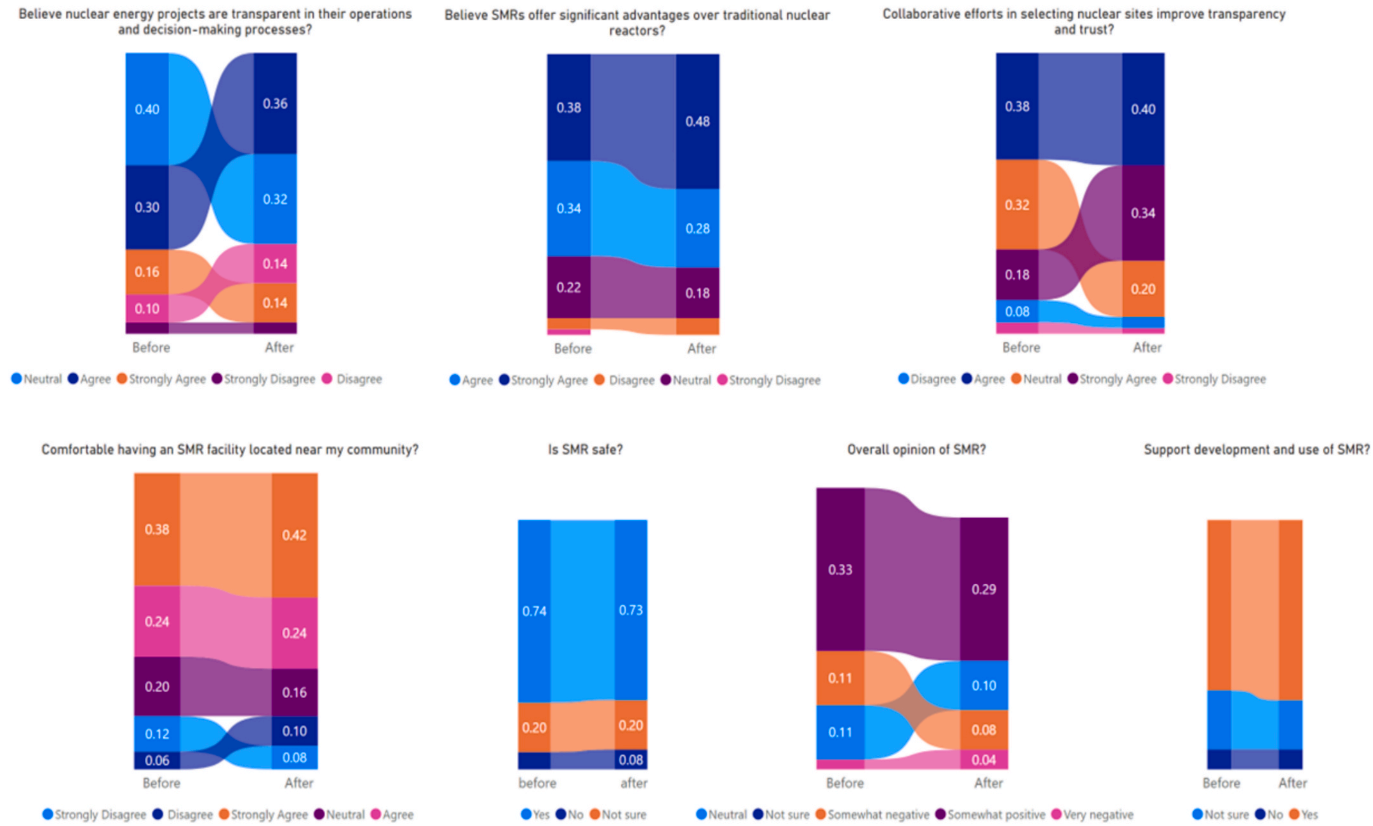

Fig. 9. Changes in attitudes toward SMRs and stakeholder engagement following information exposure.

Table 4
Marginal effects results- factors influencing overall opinions on SMRs, nuclear energy, and stakeholder engagement.

Variable	Outcome 1 Yes, I feel more positive Coefficient	Std. Err.	Outcome 2 yes, I feel more negative Coefficent	Std. Err.	Outcome 3 No change Coefficient	Std. Err.	Outcome 4 Not sure Coefficient	Std. Err.
Enhance safety features	0.202	0.160	−0.589+	0.375	0.657	0.415+	−0.270	0.258
Environmental benefits	−0.020	0.156	−0.022	0.052	0.076	0.203	−0.034	0.038
Economic advantages	−0.437**	0.182	−0.559	0.362	1.213	0.402**	−0.216	0.213
Waste management solutions	0.170	0.143	−0.585+	0.374	0.677	0.414+	−0.262	0.252
Regulation & oversight	0.261*	0.131	−0.571+	0.367	0.568	0.415	−0.257	0.248
Stakeholder engagement	0.205+	0.108	−0.614+	0.390	0.694	0.420+	−0.286	0.272
Info about SMR specially	0.377**	0.100	−0.593+	0.375	0.860	0.558	−0.644	0.567

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$.
Source: Authors.

personal well-being.

Presenting SMRs as a solution to nuclear waste showed a marginally significant reduction in negative views (coefficient = –0.585), and a marginally significant increase in "No change" responses (coefficient = 0.677). This suggests that waste-related messaging can alleviate opposition, likely by addressing a common public concern, though it does not necessarily foster positive sentiment.

Trust in regulation and oversight significantly increased positive responses (coefficient = 0.261) and marginally decreased negative responses (coefficient = –0.571). This finding reinforces the importance of institutional credibility and regulatory assurance in building public confidence and support for SMRs.

Belief in stakeholder engagement had marginally significant effects across three outcomes: it increased support (coefficient = 0.205), reduced opposition (coefficient = –0.614), and increased neutrality (coefficient = 0.694). These results highlight the value of inclusive, participatory communication, which appears to encourage acceptance and reduce resistance.

Information about SMRs specifically was among the most effective factors in shaping opinion. Providing specific information about SMRs significantly increased the likelihood of a positive response (coefficient = 0.377), and marginally reduced opposition (coefficient = –0.593). These findings underscore the importance of clear, targeted, and factual communication in moving public opinion in favour of SMRs.

Discussions

This study investigated the factors influencing public perceptions of SMRs in the UK, employing a survey-based approach to collect data. Additionally, the study assessed the role of collaborative decision-making in the nuclear site selection process, with a focus on how public engagement affects trust and acceptance of proposed SMR sites in local communities. The analysis of the findings is presented in the following sub-sections.

Key drivers of public perception of SMRs in the UK

This sub-section presents an investigation into the factors that influence public perceptions of SMRs in the UK. Public opinion on SMRs is shaped by various factors, including knowledge of the technology, proximity to proposed sites, and broader societal concerns. By examining how these factors vary across social, demographic, and geographic contexts, this research identifies the key drivers of public perception. Specifically, the study explores how informed views about SMRs (H_1) and proximity to proposed SMR sites (H_2) affect individuals' attitudes, while also considering the diversity of opinions across different population groups. The following discussion explores these findings in greater detail, highlighting their implications for public perception and the nuclear site selection process. The 90% awareness level likely reflects site-selection bias; both sites have established energy production histories and prior community consultation, meaning residents are more informed than the general UK public. A Department for Business, Energy and Industrial Strategy (BEIS) public attitudes survey found that 54% of the UK public had never heard of SMRs [40]. Findings on awareness and perception should therefore not be generalised beyond these locally informed communities.

Expected and unexpected findings

Several findings confirmed prior expectations: greater knowledge increased support (H1), proximity shaped attitudes consistent with the NIMBY literature, and nuclear waste remained a persistent driver of opposition. However, three results ran counter to expectations. Perceived environmental benefits were associated with increased opposition rather than support, suggesting that green framing can backfire when safety and trust concerns remain unresolved. Economic messaging reduced enthusiasm rather than building it, contradicting earlier studies linking economic benefits to nuclear acceptance [41]. And perceived security threats were associated with more positive attitudes toward SMRs, suggesting that awareness of their safety features may reframe rather than amplify risk concerns.

Education and perception of SMRs

Education also plays a key role, initially appearing to correlate positively with support, but further analysis reveals a more nuanced relationship. While higher education levels are associated with increased caution, slightly reducing unconditional support and increasing uncertainty. This suggests that more educated individuals are not necessarily opposed but tend to adopt a critical or evidence-seeking stance. This finding is consistent with previous research that suggests individuals with higher education levels are more likely to support complex technologies like nuclear energy, as education enhances their ability to understand and evaluate such technologies [42,43]. These findings highlight the importance of targeted, informative communication strategies that not only raise awareness but also meet the informational standards of more discerning, educated audiences.

Knowledge and perception of SMRs (H_1)

Knowledge plays a key role in shaping public support for SMRs, with greater understanding strongly linked to more favourable opinions. The provision of SMR information significantly improved participants' knowledge, increasing the proportion who felt well-informed. This rise in awareness also reduced concerns about public understanding and security threats, although concern about nuclear waste remained high. The findings of this study strongly support the first hypothesis (H_1), which posits that individuals with greater knowledge of the benefits and risks associated with SMRs will exhibit more favourable perceptions of the technology. These results align with previous research, which found that better-informed individuals tend to have more positive attitudes toward nuclear technologies [44,45]. These findings highlight the importance of providing clear, accessible information to build informed support and address key public concerns.

Environmental benefits and public perception

Unexpectedly, the analysis reveals that perceived environmental benefits have a positive and statistically significant effect on opposition to SMRs, challenging the assumption that environmental appeal naturally fosters public support. While SMRs are positioned as clean, low-carbon energy solutions, this finding suggests that acknowledging their environmental advantages may intensify resistance when concerns over safety, waste, and institutional trust are not adequately addressed. The result may reflect public scepticism, where environmental claims are viewed as greenwashing or disconnected from local realities. This highlights a critical insight: environmental messaging alone is not only insufficient but may even backfire if it fails to engage with the immediate risks and distrust experienced by communities. This finding contrasts with those of [46], who note that SMRs are often promoted as low-carbon alternatives to fossil fuels and positioned as crucial tools for mitigating climate change. However, the paradox aligns with previous studies, such as [47,48], which suggest that perceived environmental benefits do not necessarily translate into support for nuclear energy, largely due to concerns about implementation challenges and unforeseen risks.

Perceived modular construction benefits

In conclusion, perceptions of modular construction play a complex but critical role in shaping public opinion on SMRs. While some individuals express scepticism likely driven by concerns about safety, unfamiliarity, or perceived experimental risks those who recognise the benefits of modular construction are significantly more likely to support SMRs and less likely to remain undecided. The strong, statistically significant marginal effects suggest that highlighting attributes such as innovation, cost-efficiency, and scalability can effectively mobilise support and reduce public uncertainty. However, to fully leverage this positive influence, policymakers and communicators must also address existing concerns around cost, workforce readiness, and the equitable distribution of risk.

Perceived risk of accidents

Perceived risk of accidents poses a notable challenge to public support for SMRs, primarily by increasing uncertainty and reducing confidence rather than driving outright opposition. While it might be expected that higher perceived risk would lead to stronger resistance, the results suggest that many individuals with safety concerns are not firmly opposed but remain undecided. The near-equal marginal effects on reduced support and increased uncertainty point to hesitation rather than rejection. This indicates that addressing safety concerns through transparent communication, strong regulatory frameworks, and credible third-party endorsements will be essential in reassuring the public and fostering greater acceptance of SMRs.

Perceived risk of nuclear disposal/ perceived waste management

Concerns about nuclear waste disposal remain one of the most persistent and influential drivers of opposition to SMRs, with a significant positive association between perceived waste risk and negative public opinion. While these concerns do not strongly affect support or indecision, they reliably reinforce opposition, reflecting long-standing public unease around the unresolved challenges of nuclear waste management. These findings are aligned with the findings of [49,50], who identified waste management as one of the most persistent concerns in public opposition to nuclear energy. The consistently high levels of concern, even after informational exposure underscore the deep-rooted nature of this issue. However, messaging that frames SMRs as part of the solution to nuclear waste shows some potential to reduce negativity, though it may not actively build support. These findings highlight the importance of directly addressing waste-related fears through credible, transparent communication and the development of robust, long-term disposal strategies. The participatory framework proposed here focuses on reactor siting and local community engagement. However, given that nuclear waste is the most persistent concern identified in this study, site-level engagement processes should proactively include discussion of the full waste lifecycle, including the Geological Disposal Facility (GDF), even though the GDF is governed separately through the UK's Managing Radioactive Waste Safely (MRWS) programme.

Safety concerns

Perceived safety is an important factor in shaping public support for SMRs, as people who see them as safe are more likely to have a positive view. This highlights the value of clearly explaining the safety features of SMRs to help ease concerns and build trust in nuclear energy as a reliable option.

Perceived security threats

Perceived security threats, such as terrorism, appear to positively influence public opinion toward SMRs, suggesting that their perceived resilience and safety in the face of external risks may enhance their appeal. Notably, concern about security threats decreased after exposure to informational material, indicating that increased awareness of SMR safety features can help alleviate public fears. These findings highlight the importance of emphasising the security and reliability of SMRs as part of communication strategies aimed at building public confidence and support.

Perceived unproven technology

Perceptions of SMRs as an unproven technology elicit mixed responses, with some individuals viewing their novelty as a sign of innovation and potential, while others respond with mild scepticism and increased opposition. Although the effect on opposition is statistically significant, it remains small, indicating that concerns about technological maturity are present but not among the most influential factors shaping public opinion. The lack of significant impact on support or uncertainty suggests that those with doubts about the technology's readiness are more likely to form modest opposition rather than remain undecided. These findings highlight the importance of building public trust through pilot projects, transparent testing, and clear demonstrations of safety and effectiveness to reduce scepticism and foster acceptance of emerging nuclear technologies like SMRs.

Perceived regulatory challenges

Perceived regulatory challenges show a marginal but statistically detectable association with opposition to SMRs, suggesting that individuals who view the technology as hindered by regulatory hurdles may be slightly more inclined to oppose it. This likely reflects broader scepticism about institutional capacity or doubts about the feasibility of deployment, rather than a direct driver of opposition. Given the extremely small effect size, regulatory concerns appear to play a secondary role, potentially reinforcing existing doubts rather than shaping opinions independently. Overall, while not a major factor, perceptions of regulatory difficulty contribute to the wider landscape of public hesitation toward SMRs.

Perceived acceptance of SMR proximity

Proximity to SMR sites also significantly influenced public opinion, supporting hypothesis (H_2). Personal acceptance of living near an SMR facility is a strong and significant driver of support, indicating that individuals who are comfortable with local deployment are much more likely to endorse the technology. This underscores the importance of local acceptance in shaping positive public opinion. Interestingly, perceived broader public acceptance of SMR proximity is also associated with a slight increase in opposition, suggesting a more complex dynamic. This finding aligns with the "Not In My Backyard" (NIMBY) effect observed by [51], who found that proximity to nuclear sites increases local resistance due to perceived safety risks, and this study's findings reinforce this pattern, showing that proximity leads to greater opposition to SMRs rather than support. This unexpected result from this study may suggest that people doubt whether the perceived acceptance is genuine or feel uneasy about going along with what others appear to support. Together, these findings highlight the distinction between individual and perceived societal attitudes, emphasising the need to address both when promoting local deployment of SMRs.

Perceived SMRs offer advantages over traditional nuclear reactors

The perception that SMRs offer clear advantages over traditional nuclear reactors, such as improved efficiency, flexibility, and safety plays a significant role in shaping public support. The strong positive impact of this perception highlights the importance of effectively communicating these comparative benefits. The increase in agreement after exposure to information suggests that public attitudes can shift positively when these advantages are clearly explained. At the same time, the findings point to the need for clearer messaging around technical features like modularity, which may still generate uncertainty. Overall, emphasizing the unique benefits of SMRs, alongside accessible explanations of their design, is key to building broader acceptance.

Economic advantages/benefits

Although respondents often cited job creation and other economic gains as priorities, economic messaging by itself did not boost support for SMRs. In fact, emphasising financial benefits tended to reduce enthusiasm and push some people toward a neutral stance. This result contrasts with earlier studies such as [52], that linked positive economic perceptions with greater acceptance of nuclear projects. The gap likely stems from public doubts about how credible or relevant such claims are when set against more pressing concerns like safety, past nuclear accidents, and the depth of community involvement. This finding reflects a Distributive Justice concern [30]: respondents appeared sceptical that economic benefits would be fairly shared with local communities rather than accruing primarily to developers or the national grid.

Stakeholder engagement

The findings highlight the complex but important role of stakeholder engagement in shaping public attitudes toward SMRs. While overall perceptions of engagement effectiveness were mixed, there was notable optimism around collaborative site selection efforts, suggesting that transparent and participatory processes can foster greater trust. These findings align with previous research [4], which emphasised the role of transparent decision-making processes in building social legitimacy. The divided views on adopting international models like those from Sweden and Finland point to uncertainty about their applicability in local contexts, underscoring the need for tailored approaches. Statistically, belief in stakeholder engagement was associated with increased support and reduced opposition, reinforcing the value of inclusive communication and local involvement in building acceptance and reducing resistance to SMR projects. This aligns with Procedural Justice principles [30]: communities valued inclusive, transparent processes not only as a means to better outcomes, but as a marker of legitimacy in their own right.

Information about SMR specifically

In conclusion, the study reveals that while exposure to additional information about SMRs can lead to more positive attitudes, a significant portion of the public remains resistant to change due to persistent concerns about nuclear safety and waste. Preferences for trusted, traditional sources such as official websites, town halls, and newsletters highlight the need for reliable and transparent communication. Respondents emphasised improvements in update frequency, clarity, transparency, and accessibility, along with the inclusion of technical and financial details. The measurable impact of SMR-specific information on opinion further reinforces the value of clear, targeted outreach.

Together, these insights point to the critical role of strategic, trustworthy communication in shaping informed and constructive public engagement on nuclear technologies.

The survey findings indicate a notably positive baseline attitude toward SMRs, with 76% of respondents holding positive or very positive views before any information was provided, and 69% expressing support for SMR development. This compares favourably with existing evidence on public attitudes toward conventional large-scale reactors, where research in the UK context has consistently found that support is conditional and often characterised as reluctant acceptance driven by climate concerns rather than genuine enthusiasm for the technology [32]. Agreement that SMRs offer advantages over conventional reactors rose from 38% before information exposure to 48% after, suggesting that SMR-specific features do meaningfully differentiate them in public perception, consistent with the argument that serial production and reduced catastrophic risk potential may lower public fear [20]. However, the persistence of waste management concerns as the dominant barrier in this study mirrors findings from conventional nuclear research, indicating that SMRs have not fully escaped the broader nuclear stigma.

Evaluating the role of stakeholder collaboration in nuclear site selection

In addition to examining public perception, this study explored the effectiveness of collaborative decision-making in the selection of nuclear sites for SMRs. It assessed whether stakeholder collaboration influences transparency, public engagement, and the successful establishment of nuclear facilities (H_3). The findings provide insights into the relationship between these collaborative processes and public trust, as well as the broader acceptability of proposed nuclear sites in the UK. These insights set the stage for a detailed discussion of the research outcomes in the following sections.

1. Public participation and engagement

Public participation in nuclear planning remains limited, with only a few people having taken part in consultations. Those who did participate had mixed experiences, though most were more positive than negative. This shows that while the process can be useful, it still lacks the wide involvement needed to make it fully inclusive or impactful. This concern is echoed in earlier research, such as by [23], where many people felt excluded from meaningful decision-making. In many cases, opportunities for public participation are unclear or not well advertised, making people feel uncertain or disconnected. This suggests a need for better, more visible, and more inclusive ways to involve the public.

Efforts around effective stakeholder engagement is still not fully trusted by many people. While some believe in its potential, many remain unsure that their concerns are truly addressed. To build trust, it's important to clearly show how public feedback affects project outcomes. Connected to this, people often feel that their views don't influence nuclear project decision-making in a real way. This adds to feelings of distrust and a lack of openness. Similar patterns have been observed elsewhere, where weak or tokenistic community involvement in nuclear energy planning has contributed to public opposition and project delays [23].

At the same time, there's strong support for collaborative approaches to planning, especially in deciding where nuclear facilities should go. Many believe that working with communities makes the process fairer and more open. There's clear agreement that everyone affected especially local communities should have a voice in shaping these projects. This shows the importance of having inclusive and participatory planning frameworks.

However, communication from project leaders gets mixed reviews. Some people feel informed, but many want clearer, more frequent, and more open updates. This points to a need for more thoughtful and responsive communication strategies. As for international models, some are open to learning from successful examples abroad, but most people want these models adjusted to fit local needs. The UK's Managing Radioactive Waste Safely (MRWS) process is seen as a good model of stakeholder engagement [53].

There is hope that collaborative site selection can build both trust and transparency. When people see examples of how it works, their confidence grows. This shows how education and openness can shift public attitudes. Overall, people strongly believe that collaborative decision-making leads to better results more fair, balanced, and acceptable for everyone. This reinforces the need to make collaboration central to nuclear planning.

2. Trust and governance

Trust in the government to manage nuclear projects safely is cautious but improving. Before learning more, people had mixed views. After being shown clear information about modern reactors and community involvement, confidence increased. Still, worries remain about cost overruns, labour shortages, and whether taxpayers will bear the risks. Keeping trust will depend on showing strong safety records, strict rules for companies, and updates in clear, everyday language.

The biggest drivers of public trust are beliefs about safety and strong regulation, followed by care for the environment, honest communication, and real involvement from communities. People also think about money, past accidents, and news reports factors that can help or hurt trust depending on how they're handled. Trust improves when government oversight is clear and independent, and when companies explain risks and benefits honestly. But signs of secrecy, profit-first attitudes, or unclear choices can quickly weaken it. This shows how vital transparent governance and outside checks are.

Whether nuclear projects consider local social concerns is still unclear for many people. A large number aren't sure if issues like health, nature, traffic, and moving residents are really being addressed. Some feel these concerns are ignored. Nuclear-waste management is the top worry, but people also care about jobs, the local environment, and long-term well-being. When there's real public input, clear communication, and visible changes in project plans, people feel more confident that these social concerns matter.

The trust dynamics observed reflect both affective and cognitive dimensions. Affective trust, rooted in emotional responses to past accidents and institutional reputation, was evident in persistent scepticism that information alone could not fully resolve. Cognitive trust, by contrast, develops through demonstrated regulatory competence and transparent governance. The study also highlights a distinction between trust in the technology and trust in the regulator. Trust in SMRs improved following information exposure, particularly around safety and modular design, while trust in the regulator and government remained more conditional, shaped by concerns about accountability and whether public input genuinely influences decisions. Policy recommendations should address these separately: technology trust through safety demonstrations and pilot deployments, and regulatory trust through independent oversight and visible responsiveness to community concerns.

3. Communication and transparency

Clear communication about nuclear energy works best when it uses trusted and simple tools that help people learn and ask questions. Good examples include project websites, local meetings, and community newsletters. Traditional news and mail are still helpful if they offer fair and balanced coverage. People are more careful with social media, unless the information comes from trusted and independent sources. Using a mix of communication tools is most effective when messages are simple, consistent, and allow people to ask questions and get answers.

People want better communication in three main areas: how often they get updates, how clear the language is, and how honest the messages are. They ask for more regular updates in plain language, with clear details about both the good and the bad sides of projects. They also want information in different forms online, on paper, and face to face and someone they can contact if they have more questions. Many also want more technical and financial facts, not just short summaries that sound too polished. This shows that people want to be treated as informed and equal partners, not just as an audience. In the past, unclear or one-sided communication has led to confusion and public resistance, as shown in studies by [32]. The UK's MRWS process shows that sharing easy-to-understand and honest information can help reduce fear and build public trust [53].

Whether nuclear projects are open and honest is still a concern. When people get clear explanations about how the technology works and how public input is used, they tend to feel more positive. But many still don't see how their views affect the final decisions. Trust improves when people see real examples of shared decision-making and strong, independent oversight. To keep building trust, project teams need to share clear and simple information, be honest about what they don't yet know, and clearly show how community feedback leads to real changes in project plans.

4. Social and environmental concerns

Concern about the environmental impacts of nuclear energy remains strong. People are worried about how power plants and related facilities might affect nature, human health, and how land is used over time. Others feel uncertain because they do not have clear and balanced information. Confidence improves when safety rules and monitoring processes are explained in simple terms, and when people can see these systems working through actions such as proper waste management and independent inspections.

The most common concerns include nuclear waste, damage to local ecosystems, radiation exposure, increased traffic, noise, and the possibility that people may need to relocate. These concerns become stronger when communication focuses only on the positive side of projects and avoids discussing risks or how problems will be solved. People also fear that private companies might ignore safety steps to save money, putting communities in danger. To address this, project developers should carry out clear environmental assessments, listen to community feedback, and show how safety measures like secure waste storage and emergency plans are working in real situations.

5. Knowledge and perceptions of SMRs

Understanding of SMRs, or small modular reactors, was low at first. Most people were not familiar with the technology. After reading simple background materials, more people felt informed, though some questions remained. This shows the need for ongoing, clear education from trusted sources, using plain language without technical terms that confuse the public.

Concerns about SMRs are similar to long-standing fears about nuclear energy, such as how waste is handled, possible safety risks, and uncertainty because the technology is still new. Better information helped ease some of these concerns, especially those caused by lack of knowledge. However, deeper worries like managing radioactive waste are still strong. This suggests that while good explanations help, people need real evidence over time to feel fully reassured.

When asked, most people said they believe SMRs are generally safe, mostly because they trust recent designs and strict rules. Learning more increased this trust, but many also said they want outside experts to confirm that safety measures are working. For most people, safety is not just about the design but also about seeing clear responsibility and reliable long-term performance.

Overall, views of SMRs became more positive after people learned more, especially about their smaller size, flexibility, and lower costs compared to traditional reactors. Fewer people remained unsure or negative. Still, support depends on whether companies can prove they will keep their promises about safety, protecting the environment, and bringing real benefits to local communities. Keeping this support strong will require open conversations, honest updates, and clear examples that show these expectations are being met.

6. Support and acceptance of SMRs

Support for development and use of SMRs is generally strong and increases when people learn more. When given fair, balanced information about SMRs such as their modular design, cost savings, and ability to scale many people become more supportive. Still, this support is conditional. It depends on whether projects prove they meet high standards for safety, protecting the environment, and including the public.

The belief that SMRs offer significant advantage over traditional nuclear is growing. Many people think they are more flexible, possibly cheaper, and better suited to today's energy needs. This belief becomes stronger with access to real-world comparisons and case studies. But to keep support high, this belief must be backed by clear data, open communication, and honesty about risks and trade-offs.

Feeling comfortable having an SMR facility located near my community shows cautious optimism. People are more open to local SMRs when they understand how they're planned, regulated, and monitored. Comfort increases with better information but still depends on strong safety plans, emergency readiness, and visible local benefits. Keeping this comfort means listening to local concerns and showing that action is taken in response, with real follow-through.

Conclusion and policy implications

This study investigates two key questions central to sustainability and energy transitions: (1) what factors shape public perceptions of SMRs in the United Kingdom, and how these perceptions vary across social and demographic groups; and (2) how effective stakeholder collaboration has been in the identification and selection of SMR sites. The research tests three hypotheses: H_1, that individuals with greater knowledge of SMRs are more likely to hold favourable views; H_2, that proximity to proposed SMR sites is associated with higher levels of opposition, reflecting a Not-In-My-Backyard (NIMBY) response; and H_3, that stakeholder collaboration in site selection processes improves transparency, trust, and public support.

The findings support H_1, showing that higher educational attainment and factual knowledge about SMRs are associated with more favourable perceptions. However, strong concerns persist about nuclear waste, long-term safety, and environmental risks even among well-informed individuals, indicating that acceptance depends not only on knowledge but also on institutional trust and perceived responsiveness. This points to the value of education for sustainable development and accessible lifecycle information as investments in human capital.

In line with H_2, the study confirms that people living closer to proposed SMR sites are more likely to oppose development, often citing safety risks and mistrust in decision-making processes. This spatial effect illustrates how perceptions of fairness and local impact interact with broader attitudes toward nuclear energy, underscoring the need for environmental and sustainability assessment that addresses distributional effects, local risk pathways, and cumulative impacts. The age skew also raises questions under the Future Generations dimension of energy justice. Younger cohorts who will bear the longest exposure to SMR risks, including nuclear waste, were underrepresented and should be prioritised in future research [30].

Respondents weighed potential benefit faster construction, modular design, cost efficiency, and system integration against risks tied to historical nuclear incidents and institutional reliability. Support tended to weaken when projects appeared rushed, when economic benefits were framed in vague or overly optimistic terms, or when local risks were perceived as unevenly distributed. These patterns highlight the importance of fairness, clarity, and credibility in communication, alongside transparent corporate sustainability practices.

The results strongly support H_3, showing that stakeholder collaboration plays a vital role in shaping public trust. Engagement is most effective when it is two-way, sustained, and inclusive, rather than one-sided or symbolic. Communities value opportunities to ask questions, receive timely responses, and see clear evidence that their concerns influence project outcomes. Mechanisms such as town hall meetings, user-friendly official websites, plain-language newsletters, and independent technical reviews were cited as useful tools for transparency and legitimacy.

The study also highlights the role of independent oversight bodies and early-stage community involvement in planning. Embedding engagement within governance frameworks reduces perceptions of top-down decision-making and can enhance long-term support, particularly near proposed sites. Prioritising brownfield or existing nuclear locations can help manage land-use pressures, consistent with cleaner production principles of resource efficiency and waste minimisation.

By framing and testing three hypotheses, this research clarifies how public perception, spatial dynamics (including NIMBY), and stakeholder governance intersect in the deployment of emerging nuclear technologies. Policy-relevant actions include targeted public education, independent oversight, and participatory site-selection frameworks that align technical planning with community values-supporting robust sustainability assessment, inclusive decision-making, and socially acceptable low-carbon transitions.

Credit author contribution

H.H.O- Conceptualisation, Data curation, Literature Review, Formal analysis, Funding acquisition, Investigation, Methodology, Data Collection, Validation, Visualisation, Writing – original draft, Writing-review and editing.

S.M- Conceptualisation, Literature Review, Funding acquisition, Methodology, Data Collection, Writing- review and editing.

CRediT authorship contribution statement

Helen Hoka Osiolo: Writing – original draft, Writing – review & editing, Visualization, Software, Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Validation. **Swathi Mukundan:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Conceptualization.

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Declaration of competing interest

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

Data availability

Data will be made available on request.

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