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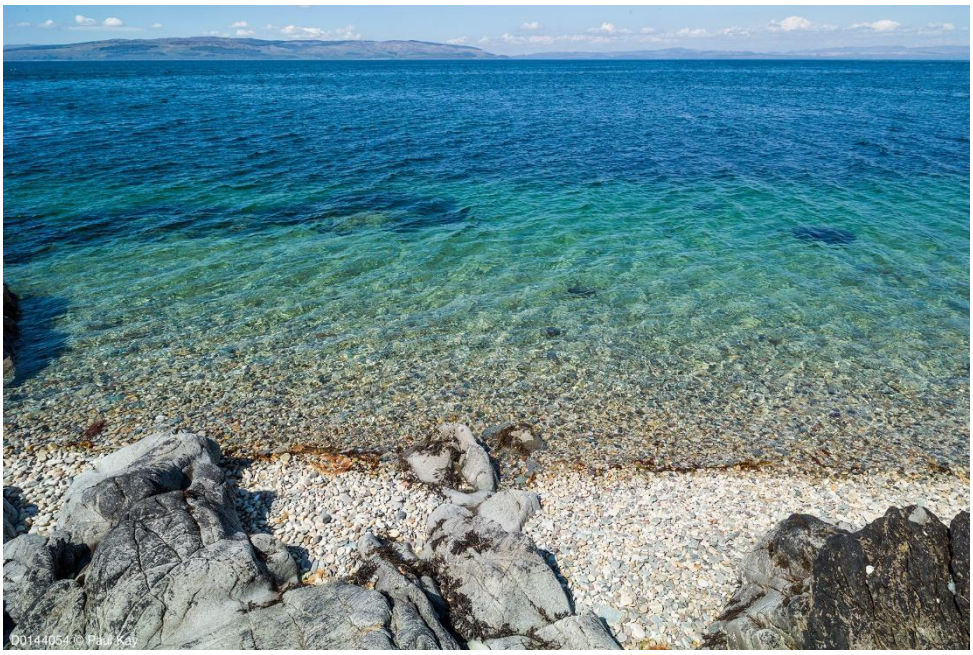
Pawan Samra

Water quality at beaches on the Isle of Arran: what do the public think?



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Abstract

Coastal water quality is a critical component of public health, environmental integrity, and sustainable recreation. On the Isle of Arran, where beaches are central to community identity and tourism, concerns around coastal water pollution are increasing despite the absence of formal bathing water designation. This study aimed to evaluate both resident and visitor perceptions of

water quality, understand origins of these perceptions, explore how they influence beach-usage patterns, and assess awareness of water quality governance and support for future management measures.

An online survey was distributed through local networks, social media, and community channels, generating 102 responses. The survey included a combination of Likert-scale, multiple-choice, and open-text questions, allowing for a mix of semi-quantitative and qualitative evaluations of the data. Statistical tests, including chi-squared and Cramer's V, were applied to assess associations across responses.

Findings revealed strong concerns about coastal water quality and its recreational impacts among residents and visitors alike. Water quality influences beach choice and enjoyment for the majority of respondents. Mental well-being was perceived to be the most valued benefit arising from a trip to beaches, particularly amongst older adults. However, awareness of how water quality is monitored/managed was limited. Few participants were aware of signage or knew how to access relevant environmental monitoring data (e.g., pollution levels). Despite this, broad support for designated bathing water status and stronger regulation exists. Respondents expressed concern about pollution from sewage, farming, and fish farms, with many calling for greater transparency in monitoring practices and clearer communication of water quality information through signage or websites.

This study highlights the importance of understanding public perceptions in shaping effective environmental policy. Findings suggest future water quality governance on Arran can benefit from improved coastal water quality monitoring, clearer communication, and collaborative (i.e., community-led) approaches.

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1. Introduction

Coastal bathing waters are central to public health, environmental quality, and local economies (Farrel et al., 2021; Börger et al., 2021). Beaches are not only sites for recreation and tourism, but also important cultural and ecological spaces that foster connections between people and the marine environment (Hawkins et al., 2016; Oliver et al., 2023). However, the growing popularity of these environments, especially during summer months, presents numerous challenges for the maintenance of safe water quality. Climate change, increased domestic and international tourism, and growing coastal development place additional pressures on bathing water environments (Payment, 2022; Tiwari et al., 2021). At the same time, there is heightened public attention on water quality and sewage discharges across the UK, and mounting concern over the health risks associated with polluted coastal waters (Altman et al., 2023; Leonard et al., 2020; Ford et al., 2025).

Bathing water quality reflects the hygienic status of coastal waters and is primarily assessed through the presence of Faecal Indicator Organisms (FIOs), such as *Escherichia coli* and intestinal enterococci (Horan, 2003; Farrel et al., 2021). These organisms signal contamination by human or animal waste and help assess the potential risk of gastrointestinal illnesses or other infections associated with water-based recreation (Leonard et al., 2020; Quilliam et al., 2019). The EU Bathing Water Directive (2006/7/EC) sets out clear standards for microbiological quality and requires regular monitoring at designated bathing sites. However, many beaches across Western Scotland and the Scottish islands, despite being popular for recreation, lack formal designation and are not subject to routine monitoring. This may be due to lower year-round population densities or seasonal visitor numbers falling below thresholds used for designation (Tiwari et al., 2021; Altman et al., 2023).

The Isle of Arran provides a compelling case study within this wider context. As a popular destination with high levels of coastal recreation and a resident population deeply engaged in marine conservation, the island presents an opportunity to better understand public perceptions of water quality in non-designated bathing areas. In the absence of formal monitoring data, public opinion can serve as an important indicator of perceived risks, cleanliness, and support for potential designation or management strategies. This study, therefore, explores how residents and visitors of Arran perceive water quality at local beaches, what factors shape those perceptions, and what the implications are for environmental management and public health protection on the island.

1.1. Water Quality: Drivers of Issues

Coastal water quality is influenced by a complex interplay of natural and anthropogenic pressures (Table 1.1.). Among the most critical are agricultural runoff, wastewater discharge, faecal pollution from human and animal sources, and the growing concern over microplastic contamination (Farrel et al., 2021; Horan, 2003; Baechler et al., 2024; Miguel et al., 2024).

In Europe, bathing water quality is legislated under the EU Bathing Water Directive (2006/7/EC), classifying designated bathing sites as ‘Excellent’, ‘Good,’, ‘Sufficient’, or ‘Poor’ based on culturable counts of Faecal Indicator Organisms (FIOs) - including *Escherichia coli* and intestinal enterococci (Horan, 2003). However, these indicators have limitations. They do not detect non-faecal contaminants (e.g., microplastics or pharmaceuticals), and results are based on routine sampling instead of real-time risks. Furthermore, required signage at designated beaches are often based on data from previous years, creating a time-lag in public information (Tiwari et al., 2021).

Table 1.1. *Key drivers of coastal water quality issues, their origins, and impacts.*

Driver	Source	Impact on Water Quality
Agricultural Runoff	Farmland nutrient and pesticide leaching	Eutrophication, increased faecal loading
Sewage & Septic System Discharge	Faulty infrastructure, overflows, tank leaks	Elevated FIO levels, visible waste, pharmaceutical chemicals
Storm surges, Sea-level rise & heatwaves	Climate Change	More runoff, harmful algal blooms, degraded ecosystems
Urban Runoff	Roads, rooftops, impermeable surfaces	Oil, sediment, litter, and chemical pollution
Microplastic Pollution	Marine debris, product breakdown	Ecosystem harm, aesthetic decline, ingestion by marine fauna
Tourism Pressure	Seasonal population peaks	Strain on waste infrastructure, increased beach litter
Fish Farming & Industrial Sources	Aquaculture, industrial outfalls	Nutrient loading, antibiotic or chemical pollution

Bathing water quality also varies spatially across the UK and is especially sensitive to land usage (e.g., proximity to agriculture or livestock), stormwater runoff, and climate patterns. On islands, such as the Isle of Arran, high rainfall and limited infrastructure can lead to combined sewer overflows or septic tank failures during extreme weather events, leading to an increased risk of coastal contamination of waters with faecal pollution.

Climate change has an amplifying effect on these issues. Warmer temperatures, sea-level rise, and increased storm frequency promote nutrient loading and coastal erosion, which subsequently

foster harmful algal blooms, which degrade water clarity; factors known to influence public perceptions and ecological risks associated with water quality (Payment, 2022).

Additionally, plastic debris and microplastics from land- and sea-based sources contribute significantly to visible pollution and have the potential to incur severe toxicological impacts on marine biota (Miguel et al., 2024). Plastics also diminish the aesthetic appeal of beaches, discouraging recreation and tourism, even if microbiological indicators remain within thresholds deemed safe.

1.2. Water Quality: Public Perceptions

Public understanding of water quality is often informed more by visible and sensory indicators than by scientific assessments (Figure 1.1.). Beachgoers typically rely on water clarity, the presence of litter, and odours as proxies for cleanliness and safety, especially in the absence of formal information or signage (Moser, 1984; Morgan, 1999; Vaz et al., 2009). Visual pollution, including plastic waste or surface debris, plays a critical role in shaping perceptions, consequently reducing public confidence and potentially deterring recreational engagement (Campbell et al., 2016; Baechler et al., 2014).

Discrepancies between scientific monitoring and public experience can create tensions, particularly where beaches are formally designated as ‘safe’ but users observe pollution or other signs of contamination. Where users perceive clean water despite poor classification - or conversely, observe pollution at a beach classified as “Excellent” - distrust in regulatory assessments may develop (Nelson, 1998; Jones et al., 2024). This disconnect can influence decisions around beach visitation and reduce engagement in environmental protection, particularly when the rationale for classification is not well understood.

Perceptions of safety are not only guided by visible indicators but also shaped by experience, hearsay, and media narratives (Figure 1.1.). Engagement with water quality management, including behavioural choices such as swimming or avoiding the water, is influenced by public awareness of local risks and monitoring procedures. However, knowledge of environmental regulations and certification remains low among many user groups. For example, beach users across Europe frequently lack awareness of schemes like the Blue Flag award or are unaware of their meanings, indicating a gap between policy mechanisms and public understanding (Marin et al., 2009; Quilliam et al., 2019).

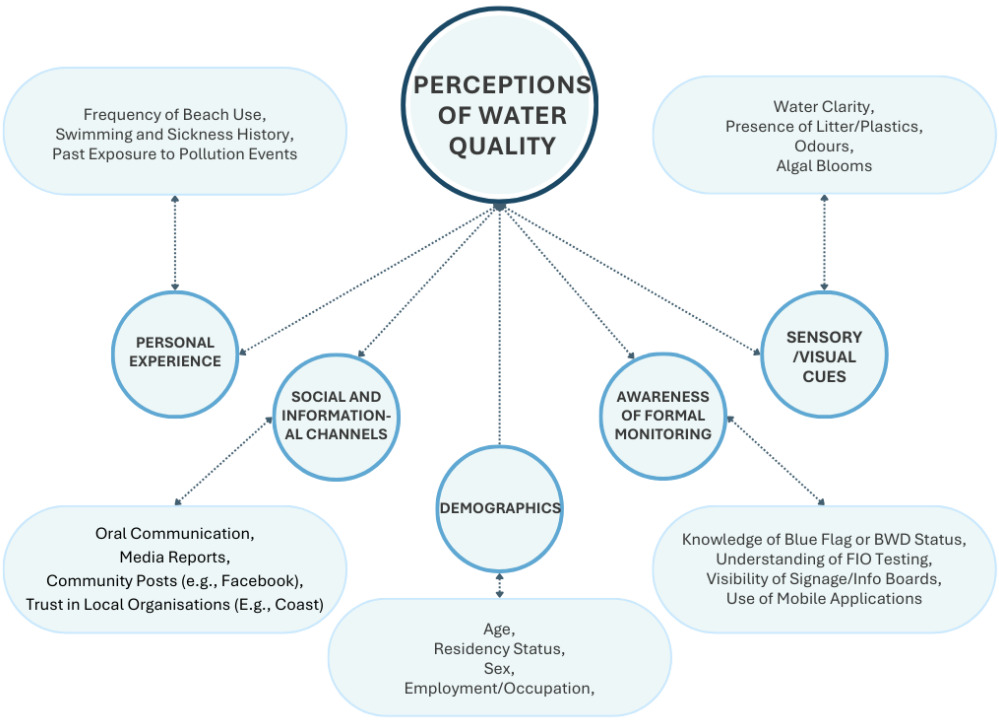

Figure 1.1. *Conceptual Flowchart illustrating the five key domains influencing public perception of water quality. Including five broad factors: Sensory/Visual Cues, Personal Experience, Social & Information Sources, Awareness of Monitoring, and Demography, all feeding into a central concept of Public Perception of Water Quality.*

Improving water quality literacy through targeted education campaigns may foster stronger senses of public ownership and boost engagement with conservation (Altman et al., 2023). A better-informed public is more likely to support management efforts and adhere to guidance issued by environmental authorities. Resident and tourist users often share common needs in terms of safety, cleanliness, and recreational suitability of coastal waters, but the efficacy of management depends on ensuring both groups are engaged in a way that matches their awareness and expectations (Marin et al., 2009; Vaz et al., 2009).

Differences in perception may also be influenced by age (Figure 1.1.). In a European cross-country study, younger individuals were more likely to demonstrate high levels of ecological awareness, whereas older respondents tended to rate water quality less critically despite potential health risks (Dobrzycka-Krahel and Fidalgo, 2025). Perceptions may also reflect social and cultural norms around risk and cleanliness, further complicating efforts to align regulatory standards with public behaviours.

1.3. Water Quality: Influence on Recreation, Use, and Behaviour

Water quality has significant impacts on recreational behaviours and beach use (Oliver et al., 2023; Börger et al., 2021; Curtis et al., 2017; Jones et al., 2024). Studies have shown that perceptions of poor water quality reduces beach visits, swimming, and a plethora of other water-based activities. A one-level deterioration in water quality classification under the EU Bathing Water Directive (BWD) has been suggested to lead to 20.83% fewer visits to a designated bathing water beach (Börger et al., 2021; Jones et al., 2024). However, even where scientific assessments of water quality deem waters unsafe, the majority of the public will still visit a beach, but they will then likely avoid the water (Figure 1.2.). In many cases, the visual presence of contaminants (e.g., litter, algae, or discoloured water) triggers the avoidance of entering the

water, even if official assessments suggest the site remains safe. For families in particular, advisories and poor visual water quality indicators significantly reduce the likelihood of visiting a beach for recreation (Jones et al., 2024).

Bathers who are exposed to polluted coastal waters tend to have significantly higher prevalence of gastrointestinal and respiratory illnesses when compared to non-bathers (Leonard et al., 2020). These health concerns can act as strong deterrents towards recreational use (e.g., boating), with significant implications for tourism and associated coastal economies (Curtis et al., 2017; Börger et al., 2021).

Beyond physical health, aesthetic factors such as plastic and microplastic pollution also diminish the appeal of coastal environments. Their presence reduces beach attractiveness and can discourage visits, particularly among those concerned about marine wildlife welfare (Baechlar et al., 2024; Miguel et al., 2024).

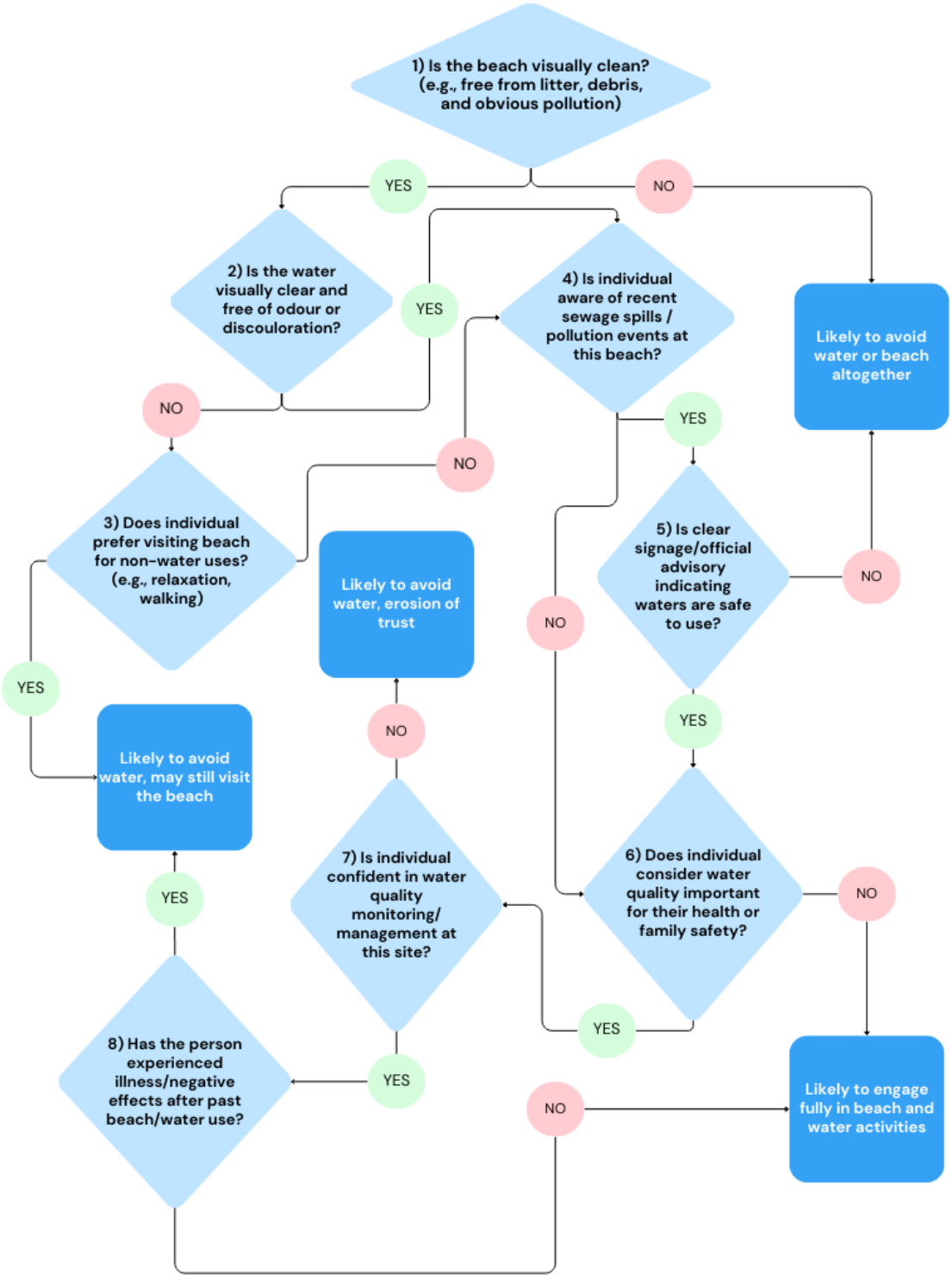

Figure 1.2. *Decision-making framework outlining key factors influencing beach users' decisions to engage in water-based recreation. The diagram presents a sequence of yes/no decisions reflecting how beach users may assess water quality before participating in recreational activities. Factors include*

visible pollution, previous experiences, available water quality information, and perceived health risks guiding an individual's behavioural outcomes. Outcomes range from full water engagement to beach use only, or complete avoidance and increased distrust in water quality management and monitoring.

Additionally, demographic factors further influence public perceptions and beach usage (Figure 1.1.). Mental wellbeing was a more valued benefit than physical health across all but one age group when examining Scottish open water swimmers (Oliver et al., 2023); those aged 65 or over identified physical benefits as their most important outcome. However, younger participants exhibited a greater tendency to cancel/cut short swims due to concerns about water quality, suggesting age-related differences in risk perception and consequent behavioural response.

Arran, as a small island community heavily reliant on its natural environment for recreation and tourism, is particularly vulnerable to water quality degradation. Maintaining high standards is essential not only in safeguarding public health but also for supporting the island's reputation and economic sustainability. Given the absence of formal bathing water designation across many of the beaches, Arran presents itself as an important case for exploring how perceptions of water quality influence recreational behaviour and community support for environmental management.

1.4. Water Quality: Economic Implications

There are significant economic consequences that arise from poor coastal water quality, particularly for island and tourism-dependent regions such as the Isle of Arran. Evidence from across Europe shows that when pollution concerns arise - whether real or perceived - tourists increasingly avoid affected areas in favour of cleaner alternatives. This shift in visitor behaviour results in substantial losses to local businesses, including those reliant on marine recreation such as boating, diving, and beach-side hospitality (Morgan, 1999; Curtis et al., 2017).

A one-level improvement in bathing water classification under the EU BWD can lead to ~ 3.13 additional annual visits per person, increasing individual recreational value by around €129.25 (Börger et al., 2021). When extrapolated across all blue space sites in 14 EU countries, this equates to a total potential recreational value increase of nearly €42 billion. Conversely, a drop in classification could cost the EU blue-space economy over €1 billion annually. This reinforces the need for continued investment in water quality improvements – not only as a public health imperative, but also as a long-term strategy supporting sustainable tourism and local livelihoods. For regions like Arran, where the coastline plays a central role in attracting visitors and supporting the local identity, maintaining high water quality standards is critical not only to the ecosystem's health but also to the island's economy. Although providing compelling evidence at a European scale (Börger et al., 2021), the economic model does not fully account for the unique demographic, geographic, and seasonal characteristics of small island communities like the Isle of Arran, where visitor trends and local perceptions may differ significantly.

1.5. Public Engagement and Environmental Management

Public engagement in water quality monitoring and local conservation initiatives is vital for sustainable coastal management. Trust in regulatory agencies, access to data, and participation opportunities for the public significantly influence the levels of involvement from individuals (Altman et al., 2023). Despite this, many communities remain excluded from formal decision-making processes. This exclusion often leads to a sense of detachment or lack of ownership over water quality outcomes and associated policies (Ravenscroft and Church, 2011).

However, community-led water monitoring programs in Costa Rica successfully increased policy enforcement and public awareness of water quality issues, providing evidence that local engagement bolsters public efforts for conservation (Shahady and Boniface, 2018). Thus, more

inclusive approaches, such as co-designed policies, participatory governance frameworks, and citizen science initiatives, which empower local actors to contribute to environmental monitoring and management, can foster trust and also increase the likelihood of communities complying and undergoing long-term behavioural changes for the betterment of coastal waters (Altman et al., 2023; Shahady and Boniface, 2018).

Alongside innovation in governance, technological developments are opening up new pathways for public engagement. The creation of digital platforms, alongside using process-based and statistical modelling, enables near real-time pollution alerts, and updates on bathing water quality, as well as historical trends (Miller et al., 2025; Tiwari et al., 2021). These systems can increase transparency by directly giving public access to monitoring data, so they can visualise risks in accessible ways and improve their ability to make informed decisions. These platforms also offer regulators and local organisations new tools to communicate water quality risks and interventions effectively, closing the gap between scientific assessments and public understanding.

On Arran, where formal bathing water monitoring is currently absent, empowering communities through accessible water quality information and participatory approaches could play significant roles in improving public trust and stewardship towards their coastal environments. However, these strategies come with limitations, e.g., digital access, varying levels of environmental literacy, and the capacity of local organisations to implement such engagement initiatives.

Although traditional water quality monitoring relies on FIO detection, such as *E. coli* and intestinal enterococci, emerging technologies offer opportunities to improve data accessibility and transparency (Horan, 2003; Tiwari et al., 2021). For instance, AI-driven modelling and Internet of Things (IoT) sensors can provide real-time environmental updates and pollution

alerts, which may help increase public engagement and trust in water quality monitoring systems (Miller et al., 2025; Chavhan et al., 2025). However, the relevance and feasibility of implementing such innovations remain limited in smaller communities such as Arran, where digital infrastructure and public awareness might not yet support such systems. Further research is required to assess whether these tools can be effectively used to complement community-led as well as traditional regulatory water quality monitoring approaches.

1.6. Literature Gaps

Despite growing research surrounding coastal water quality, public perceptions, and management strategies, several important gaps remain. Firstly, there is a clear geographic gap in the literature, with a disproportionate focus on urban and mainland coastal regions. Rural and insular communities, such as the Isle of Arran, are frequently underrepresented. One reason is that these areas are often excluded from formal water quality monitoring due to cost-effectiveness constraints and lower visitor numbers, not meeting criteria for designated bathing water sites under the BWD. For example, in Scotland, the Scottish Environmental Protection Agency (SEPA) only monitors locations with sufficient evidence of frequent bathing activity. This creates a critical gap in data for areas still hosting large visitor and local numbers, undergoing high levels of recreation during peak seasons.

In addition, emerging evidence suggests a strong public hunger for more transparent information about local water quality, even at beaches falling outside formal monitoring networks. A tension builds, while more remote areas are less likely to be prioritised by national monitoring schemes, the public still perceives waters as important for the community's recreation/wellbeing. This research addresses this disparity by exploring water quality perceptions, awareness, and

behaviours on the Isle of Arran as a case study, where formal designation and monitoring is currently absent.

While many studies have explored general public attitudes toward water quality, relatively few investigate how perceptions influence specific behaviours, e.g., frequency of beach visits, swimming, or support for water quality initiatives. Limited research captures public awareness differences between resident and visitor users, or across different demographic groups, particularly in coastal rural areas such as Arran.

Finally, a scope exists to better understand the roles of community-led engagement and citizen science in bridging gaps between formal monitoring and public trust. Co-designed approaches and local initiatives are great in gaining traction; however, further research is necessary to evaluate their efficacy in improving water quality education and informing environmental management at a community level.

1.7. Study Aim and Objectives

Maintaining high coastal water quality is vital for public health, sustainable tourism, and environmental integrity/protection. On the Isle of Arran, beaches are important community and recreational blue spaces, yet no formal bathing water designation or regular monitoring currently exists. As a result, community perceptions, behaviours, and experiences offer valuable insights into the local water quality conditions and the public's need for improved management.

The overarching aim of this study is to explore public perceptions of coastal water quality on the Isle of Arran and assess how these perceptions influence recreational use, support for water quality monitoring, and attitudes toward environmental management.

Four objectives were developed to address this aim: (i) assess the influence of demographic and behavioural factors (e.g., age, residency, beach usage) on perceptions of coastal water quality;

(ii) explore how perceived water quality impacts recreational behaviours and beach activities, including swimming, family visits, and other beach uses; (iii) evaluate public awareness, trust and support for water quality monitoring and management initiatives, with a focus on local agencies and communication gaps; (iv) investigate attitudes toward potential designation of Arran's beaches as official bathing waters, and the perceived environmental and economic impacts of poor water quality.

2. Methodology

2.1. Sample Site

An online survey was conducted on the Isle of Arran, a Scottish Island located in the Firth of Clyde. The island is approximately 432 square kilometres in area and is often referred to as "Scotland in miniature", combining Highland and Lowland landscapes. Tourism plays a vital role in Arran's economy, generating over £76 million in economic impact in 2022 and supporting more than 1,300 full-time equivalent jobs—a significant contribution for an island with a resident population of just over 4,500 (Tipler, 2023). Arran experiences substantial seasonal variation, with approximately 373,000 visitors recorded in 2022 and over 848,000 tourist days, the majority of which occurred between May and September (Tipler, 2023). This pattern was further reflected in the 2024 VisitArran Visitor Survey, where over 60% of respondents indicated visiting during this peak period (VisitArran, 2024). Arran is served by ferry connections from Ardrossan to Brodick as well as from Lochranza to Claonaig, supporting both residents and the tourism economy (North Ayrshire Community Planning Partnership, 2017).

The survey focused on eleven beaches around the island that are frequently used by the public: Lamlash, Whiting Bay, Blackwaterfoot, Brodick, Kildonan, Sannox, Kilmory, Lochranza, Pirnmill, Corrie, and Machrie (Figure 2.1.). Additional locations were within the scope of the survey through an "Other" option. These beaches vary in terms of infrastructure, accessibility, popularity, as well as proximity to population centres.

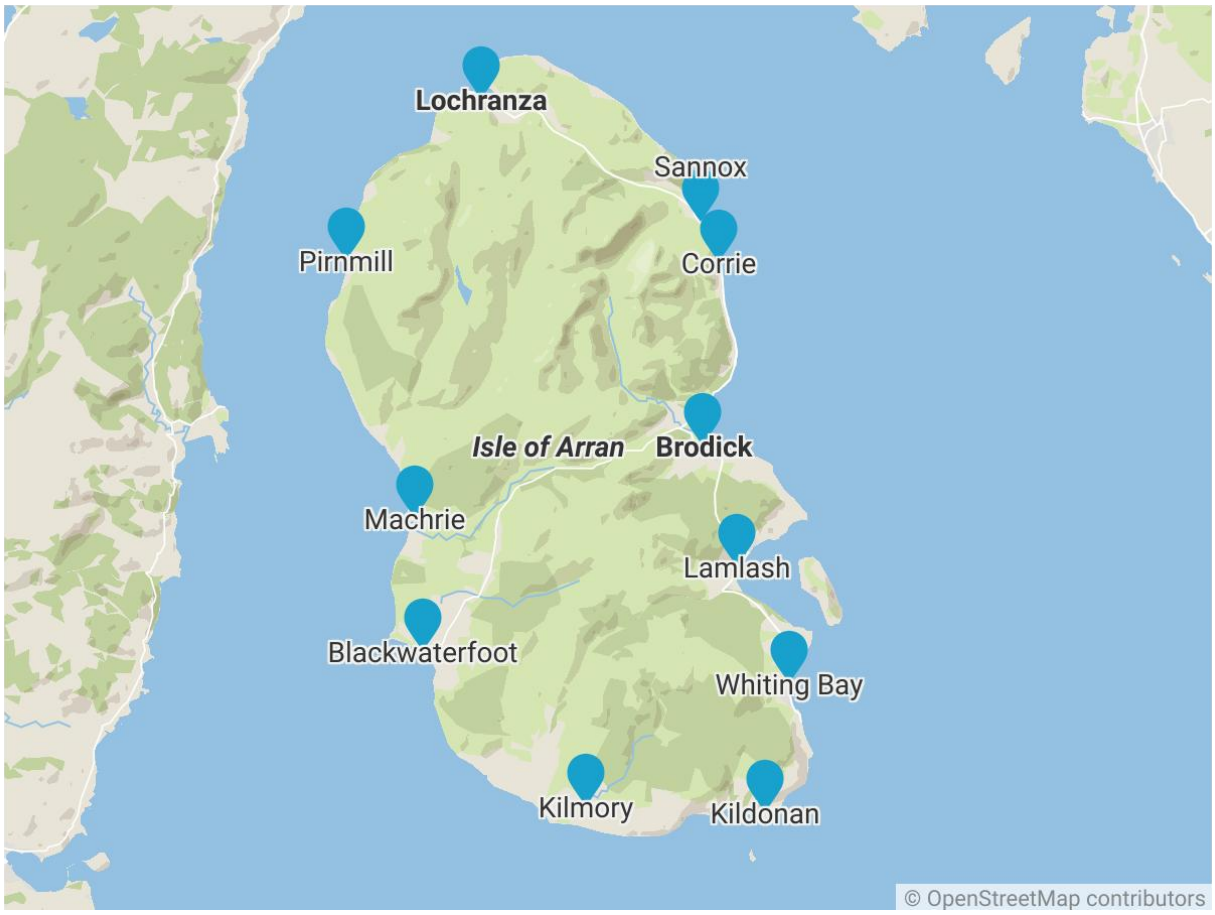

Figure 2.1. *Map of The Isle of Arran. The study area shows the eleven main beach locations on Arran within the scope of the study. Locations in bold represent ferry transport links.*

Including a wide geographical scope of beaches, the study reflects a diversity of coastal use and the broad environmental conditions across Arran. This broad selection ensured perceptions and beach usage patterns could be gathered across coasts, tourist hotspots and remote areas, and from beaches of varied environmental quality and recreational value. The broad scope allowed for the

identification of patterns associated with specific locations, whilst also supporting island-wide understanding of public perceptions regarding water quality.

2.2. Data Collection

Data were collected through an online questionnaire developed and hosted on JISC 'Online Surveys' software (https://www.jisc.ac.uk/). The survey comprised 27 questions aimed at capturing public perceptions, knowledge, and concerns surrounding coastal water quality on the Isle of Arran. Topics included individual experiences, beach usage patterns, and awareness of environmental management strategies. Prior to launch, the survey was piloted with a small group of individuals, resulting in only minor modifications to question wording required for clarity refinements. A full copy of the final survey is included in the appendix (Table 7.1.).

To ensure broad participation across different demographics and groups of interest, the survey was distributed through multiple channels. Key promotional support came from COAST (Community of Arran Seabed Trust), whose established networks and strong community ties were instrumental in reaching out to local stakeholders and communities. The survey was shared with VisitArran (the island's local tourism body) to encourage survey dissemination through weekly business bulletins, which targeted hospitality providers and other enterprises interested in water quality. Additional outreach was gained through targeted Facebook groups such as "Arran Local Community Forum", "Arrans Locals Scotland", "Isle of Arran: Outdoor Forum", "Arran Open Water Swimmers", and "Arran Snorkelling". Furthermore, posters were designed and distributed across key locations on the island to engage both residents and visitors. Social media activity was maintained throughout the collection period to boost the rates of survey responses. The survey was live from 21st October 2024 to 21st January 2025, including a combination of Likert-scale, multiple-choice, and open-text questions. The survey was preceded by a participant

information sheet and electronic consent form, ensuring respondents were fully informed about the purpose of the research and how their data would be handled. Ethical approval for the study was granted by the University of Stirling General Ethic Panel, and data was collected in accordance to guidelines. A total of 102 participants completed the survey.

2.3. Data Analysis

The survey gathered predominantly categorical data, including responses from multiple-choice, Likert-scale, and open-text formatted questions. Prior to analysis, data were cleaned to ensure consistency and remove any incomplete entries. Likert-scale responses were collapsed into three categories (“Agree”, “Neutral”, “Disagree”) to improve statistical validity when tests had smaller subgroup sizes. Open-text responses were thematically analysed, identifying recurring patterns, key concerns, as well as illustrative quotes from respondents.

Quantitative analysis was performed in RStudios version 4.4.2 (Posit Team, 2025) by using a combination of data wrangling, plotting, and statistical testing packages. First, descriptive statistics were used to summarise overall response distributions for each question. Visualisation was conducted using bar plots and grouped or stacked bar charts (with percentage-based comparisons) to improve interpretation. When possible, cross-tabulated plots were created to compare responses across demographic subgroups such as age, residency status, or most frequently visited beach.

To test for associations between categorical variables, Chi-squared (χ^2) tests of independence were used. These tests were based on raw counts rather than percentage data, in accordance with normal practice for categorical analysis. For relationships that achieved statistical significance ($p < 0.05$), Cramer’s V was calculated to assess the strength of association between variables.

Interpretative thresholds for Cramer's V were: Very Strong (> 0.25), Strong (> 0.15), Moderate (> 0.10), Weak (> 0.05), and Very Weak to None (≤ 0.05) (Akoglu, 2018).

Data analysis focused on identifying statistically relevant differences in perceptions and usage patterns across key groups (e.g., residents vs. visitors, or different age groups), in line with the research objectives. This approach provided the foundation necessary for interpreting trends in beach usage, perceived water quality, in addition to public awareness of environmental management across the Isle of Arran.

3. Results

3.1. Sample Representativeness

A total of 102 individual perceptions were collected from the survey. Of these, 70 individuals identified as residents of the Isle of Arran, while 25 identified as visitors. A small number of respondents selected "other" and specified alternatives such as part-time residency.

The most frequently reported age profile was 55-64, accounting for 33% of total responses (Table 3.1.). This was followed by age groups of 65+ (23%) and 45-54 (19%). The 18-24 and 25-34 categories were less represented in the sample. There was no statistically significant association between age group and residency status ($\chi^2 = 12.55$, df = 10, p = 0.250). This suggests that the age distribution of respondents did not differ significantly between residents and visitors.

Table 3.1. *Summary of respondent demographics (n = 102), including age, residency, gender, and employment status.*

Response	Age	Employment	Gender	Residency
55-64	34 (33.3%)	-	-	-
65+	23 (22.5%)	-	-	-
45-54	19 (18.6%)	-	-	-
35-44	12 (11.8%)	-	-	-
25-34	10 (9.8%)	-	-	-
18-24	4 (3.9%)	-	-	-
Full-Time	-	36 (35.3%)	-	-
Retired	-	32 (31.4%)	-	-
Part-Time	-	29 (28.4%)	-	-
Student	-	2 (2%)	-	-
Unemployed	-	2 (2%)	-	-
Prefer not to say	-	1 (1%)	-	-
Female	-	-	72 (70.6%)	-
Male	-	-	30 (29.4%)	-
Resident	-	-	-	70 (68.6%)
Visitor	-	-	-	25 (24.5%)
Other	-	-	-	7 (6.9%)

Skewed gender data indicated that 71% of respondents were female, and 29% were male. The majority of respondents reported their employment status as either “Full-Time” (35%), followed by “Retired” (31%) and “Part-Time” (28%). Ultimately, good coverage of responses, reflecting the Isle of Arran’s population dynamics, was collected.

3.2. Public Perceptions of Water Quality

Respondents were asked to indicate their level of agreement with five statements relating to coastal water quality on the Isle of Arran. Each question used a five-point Likert scale: 'Strongly Disagree (SD)', 'Disagree (D)', 'Neutral (N)', 'Agree (A)', and 'Strongly Agree (SA)' (Figure 3.1.). Participants were asked if coastal water quality impacts enjoyment, which was met with high levels of agreement, with 41% selecting A and 49% selecting SA; no respondents selected SD. When asked if water quality influences beach choice, 38% of respondents agreed, 38% SA, no respondent strongly disagreed. Mixed responses were gathered when asked if there had been times when users had decided not to swim due to water quality concerns, with 16% SA and 23% agreeing, while 25% were neutral and 25% disagreed. 39% of participants SA to having a long-term concern for the marine environment, followed by 31% agreeing and 17% selecting neutral, while 12% disagreed and one individual selected SD. Overall, 56% of respondents selected neutral when asked if water quality around Arran has improved over the last 5 years, followed by 20% agreeing and 20% disagreeing.

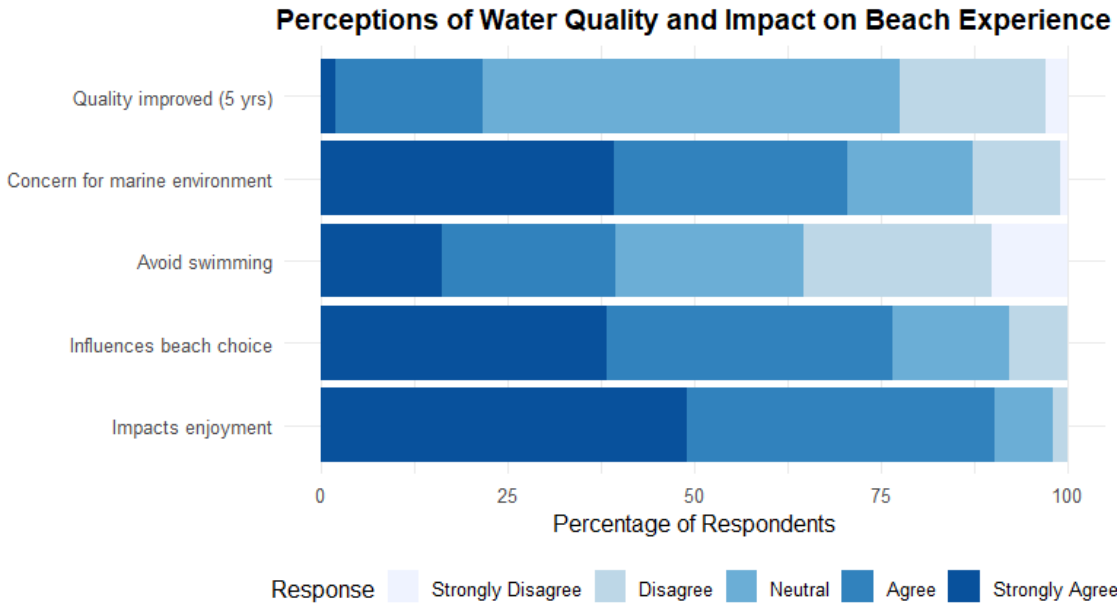

Figure 3.1. *Respondent levels of agreement with statements relating to coastal water quality on the Isle of Arran are shown as a percentage total. Individuals were asked the following questions: Coastal water quality impacts on my enjoyment of my visit to the beach; Water quality will influence my decision of which beach to visit; There have been times when I have decided not to swim in the sea around Arran due to water quality concerns; I am concerned about the long-term impacts of water quality on the marine environment around Arran; The water quality at beaches around Arran has improved over the last 5 years.*

No significant associations were found between residency status and agreement with the following statements: coastal water quality impacts beach visit enjoyment, water quality influences beach choice, or that respondents had previously avoided swimming due to water quality concerns (all $p > 0.05$). Similarly, no significant association was observed between age group and concern for long-term marine environmental impacts ($p > 0.05$).

In contrast, a statistically significant association was found between residency status and perceptions of whether water quality improved over the last five years ($\chi^2 = 10.32$, $df = 4$, $p = 0.035$), Cramer's V indicated a very strong association ($V = 0.33$). The test revealed that residents mostly disagreed that water quality improved, while visitors selected neutral responses.

Respondents were asked to expand on their general perceptions of water quality at Arran's beaches. A total of 77 responses were received with several common themes emerging (Table 3.2.). The most commonly reported ($n = 31$) concerns related to sewage and septic tank pollution - for example, recent incidents of leakage, overflow after rainfall, and visible waste along the shorelines.

Table 3.2. *Summary of key themes and example quotes from open-ended responses on water quality.*

Theme	Description	Example Quotes
Sewage & Septic Tank Pollution	Mentions of sewage leaks, burst pipes, or failing septic systems, often after heavy rain.	"Recent sewage leakage at Brodick beach is highly concerning... there was a strong stench." "Faeces visible in the water by septic tank outlets." "Raw sewage left on the beach after heavy rain."
Concerns About Fish Farming	Pollution or seabed impact attributed to fish farms, especially in Lamlash.	"Fish farms have a huge impact on water quality in Lamlash." "Fish farm pollution affects the seabed." "Waste dumped outside Whiting Bay."
Perceived Decline in Quality	Observations of increasing plastic, debris, algal blooms, or worsening conditions.	"Plastic pollution and oil floating around the shorelines." "Microplastics have increased noticeably." "Algal blooms in the summer have been worrying."
Positive or Neutral Perceptions	Statements suggesting water quality is good, unchanged, or clear to the eye.	"Arran's beaches are clean and the water is clear."

Theme	Description	Example Quotes
		"The sea nearly always looks clear." "Never had any issues swimming."
Lack of Information	Comments indicating low awareness of monitoring or reliance on water appearance alone.	"No published water quality information available." "I go by water clarity and debris." "No idea how to check quality."
Trust in Local Conservation	Support for COAST, the No Take Zone, or local stewardship of water quality.	"The No Take Zone has had a positive benefit." "COAST is monitoring water health." "COAST has made big improvements."
Uninformed / Not Relevant	Responses indicating no strong opinion, not swimming, or not enough experience to comment.	"I don't swim, so not relevant." "Not informed enough to say." "Just moved here recently."

Several participants (n = 14) also raised concerns about pollution from fish farming, particularly in Lamlash, which was frequently mentioned as an area of concern. Other individuals (n = 18) described a perceived decline in water quality, referencing increases in plastic waste, algal blooms, or oil residue.

In contrast, many respondents (n = 23) expressed positive/neutral perceptions, describing water as clear and clean, noting the abundance of marine life. Some participants (n = 10) indicated a

lack of reliable information about water quality and relied on visual cues or personal experience instead. Finally, a small group of responses (n = 5) expressed support for local conservation efforts, including the No Take Zone and COAST's work to restore and protect marine environments.

3.3. Origins of Perceptions

Respondents were asked to identify all the causes they believed contributed to poor water quality at Arran's beaches (Figure 3.2.). The most frequently selected cause was 'microplastic particles resulting from breakdown of waste plastic', selected by 83% of participants. This was followed by 'faecal bacteria from land-based human sewage sources and farming' at 80%, and 'nutrient runoff from farming, forestry or other land-based activities' (64%).

Over half of respondents also selected 'petrochemical discharges and residue from ships and boats' (56%), 'nutrient and chemical inputs from aquaculture' (57%), and 'faecal bacteria from sewage discharges from marine craft' (51%).

'Sediment from field, forestry and road runoff' was less commonly selected at 43%. Additional responses provided under 'other' reflected a range of localised or specific concerns. These issues include fish farm waste, runoff from golf courses and distilleries, discarded litter and animal faeces, and chemical or pharmaceutical residues associated with sewage overflows.

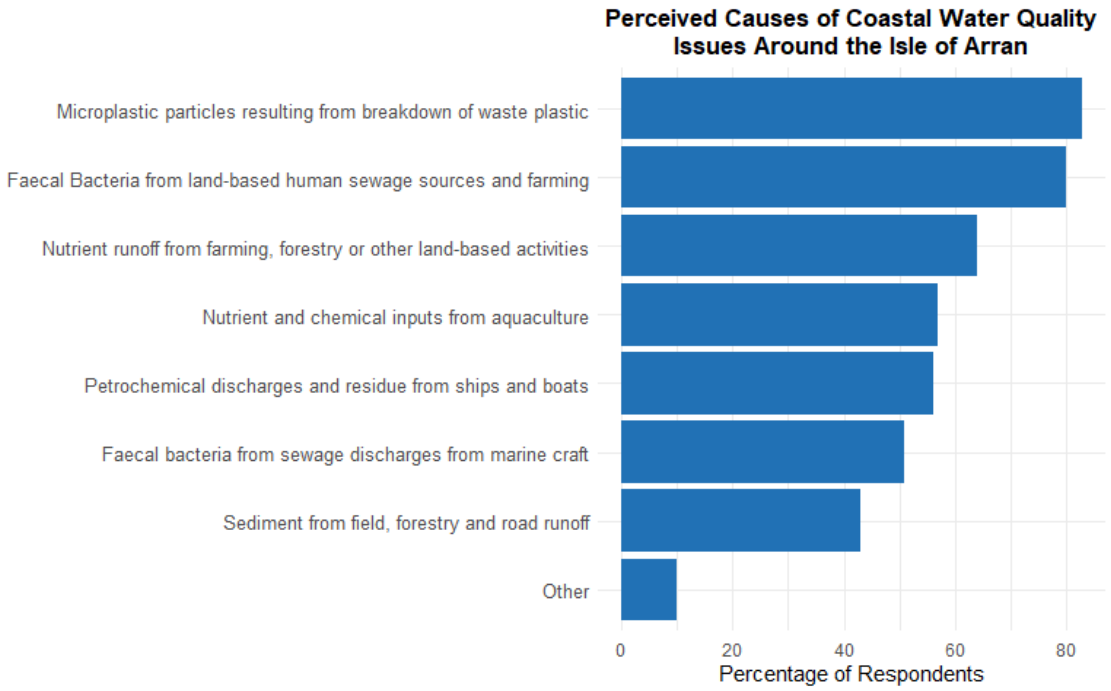

Figure 3.2. *Perceived causes of water quality issues around Arran, based on survey responses. Values represent the percentage of respondents selecting each cause.*

When asked to identify the single most important problem affecting water quality on the Isle of Arran's beaches, almost half (48%) of respondents selected 'faecal bacteria from land-based human sewage sources and farming'. In total, 16% identified 'microplastic particles resulting from the breakdown of waste plastic', and 10% selected 'nutrient and chemical inputs from aquaculture (Figure 3.3.).

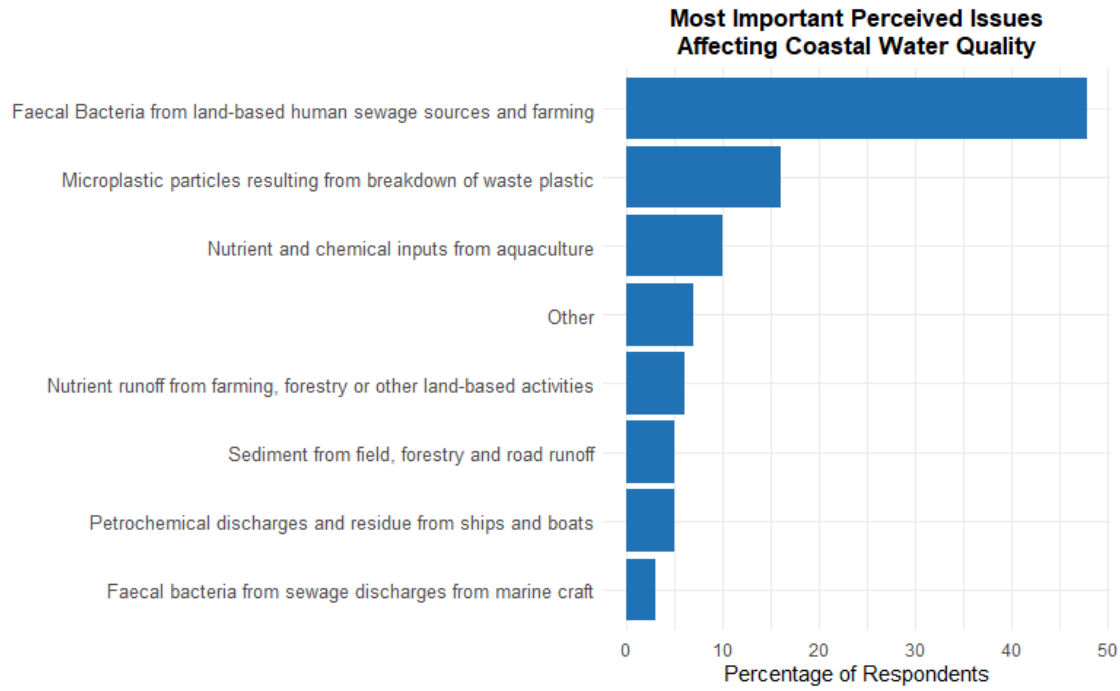

Figure 3.3. *Most important water quality issue as identified by respondents. Results are displayed as percentage of total responses across available categories.*

Open-text responses under 'other' revealed a range of views. Several respondents expressed uncertainty or felt unable to assess the primary cause of poor water quality without scientific data. Others suggested that the issue was multi-factorial and could not be attributed to a single source. Few people mentioned litter and concerns about boat waste discharges. These responses suggest participants view water quality as being affected by a complex interplay of these sources. No significant associations were found between residency status and the issue respondents identified as the greatest contributor to poor water quality ($p > 0.05$). Similarly, there were no significant differences between residents and visitors in their beliefs about the causes of poor water quality, nor were any significant differences found across age groups (all $p > 0.05$). While the pattern of these responses suggests some variation in perceived pollution sources, these were not statistically significant, likely reflecting both a shared concern across groups as well as the limitations of the sample size.

3.4. Water Quality Impact on Beach Usage

Users were questioned on their views on the most important benefit gained from beach visits (Figure 3.4.). Across all age categories, the most common benefit was mental wellbeing, described as “engaging with nature”. No significant relationship was found between age group and the most important benefit ($p = 0.518$), although the trend suggests a shared emphasis on mental wellbeing across the sample.

Among the youngest age category (18-24), 75% selected mental wellbeing as their primary benefit, and 25% chose physical exercise. A similar pattern was observed in the 25-34 age group. In the 35-44 group, responses varied, 50% selected mental wellbeing, 25% chose social benefits and 16.7% selected physical activity.

Respondents aged 45-54 selected mental wellbeing (63.2%) as their greatest benefit, 31.6% chose physical recreation, and a few selected social interactions (5.3%). This pattern was also observed in the 55-64 age group. Finally, in the 65+ group, 52.2% prioritised mental wellbeing, 34.8% physical recreation, and 8.7% selected social connection.

The results suggest consistent preferences for mental health benefits across all age groups, particularly among younger and middle-aged respondents. Physical activity remains important - especially in older users - however, social interaction was selected far less frequently overall.

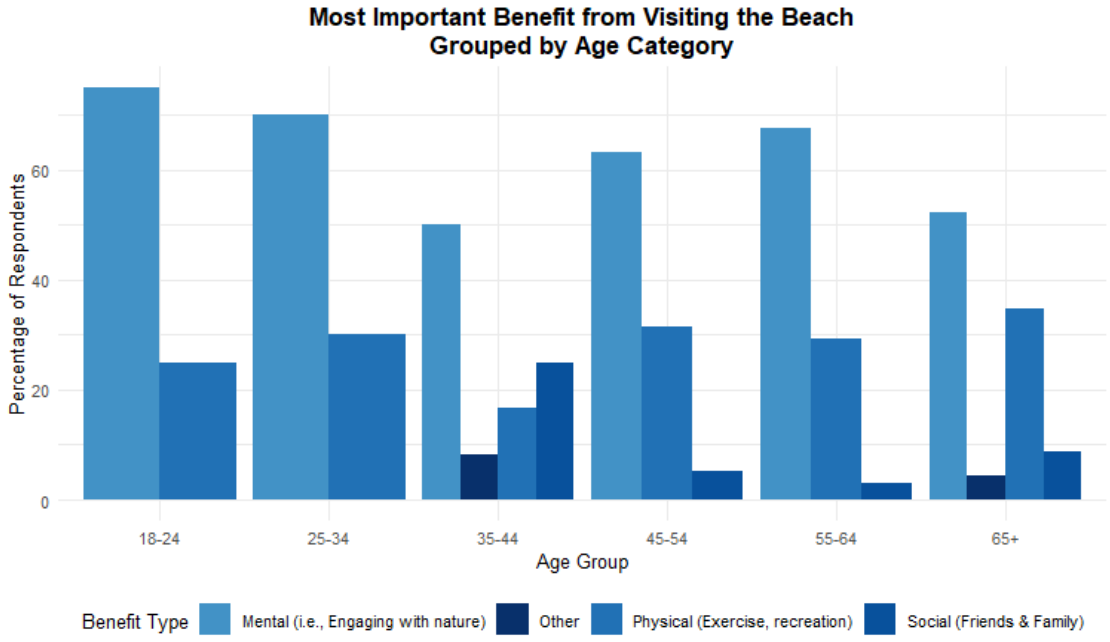

Figure 3.4. *Primary benefit of beach use by age group. Benefits include mental wellbeing, physical exercise, social connection, and other categories. Displayed as percentage of responses within each age group.*

Participants were asked to identify three activities they undertake the most when visiting Arran's beaches. Across all age groups, the most commonly reported activities were walking/dog walking, followed by relaxation/scenery, and swimming/bathing (Figure 3.5.). Younger respondents (18-34) were more likely to select craft-based water sports, swimming/bathing, with the 18-24 age group selecting diving/snorkelling (~ 25%). Older age groups (35+) favoured relaxation, wildlife watching. Activities such as diving/snorkelling and family activities, and 'Other' were less frequently selected across most age groups.

The results suggest clear age-related differences in recreational beach usage. Physically active and water-based activities are favoured by younger groups, and more passive/observational activities are preferred by the older demographic. A series of tests confirmed significant

associations between age group and activity choice, with significant associations for “Family Activities” ($p = 0.009$, Cramer’s $V = 0.387$) and “Walking/dog walking” ($p = 0.012$, Cramer’s $V = 0.379$), both showing very strong associations. “Family Activities” were most commonly selected by respondents aged 35-44 (56%), followed by a smaller proportion of those aged 25-34 (13%). This suggests that family-oriented recreational use is more prominent among younger and mid-aged adults, likely reflecting life stage. In contrast, “Walking/dog walking” was more prevalent among older age groups, particularly those aged 55-64 (97%) and 45-54 (93%). Even the 65+ group showed high participation (81%). Other activity differences, e.g., diving/snorkelling or wildlife watching, showed moderate variation across age groups but were not statistically significant, further suggesting an age determinant on beach engagement. These results imply that beach-based walking is strongly associated with older users, while younger groups favour more active or family-based use.

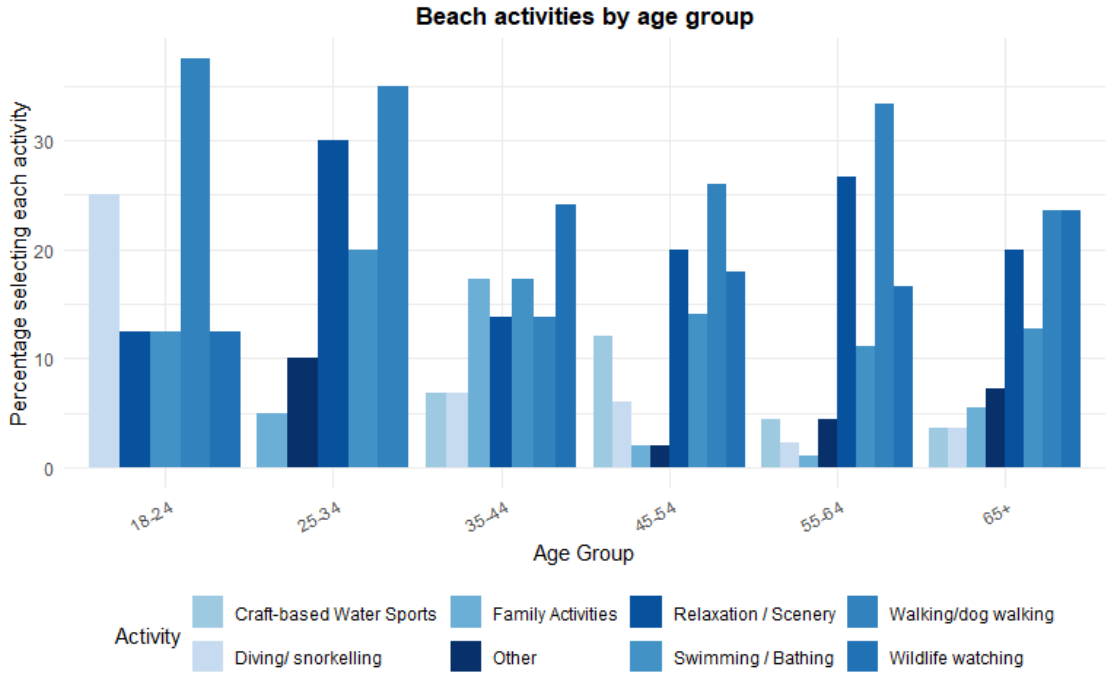

Figure 3.5. *Beach-based activities reported by respondents, grouped by age category. Responses are presented as percentage of respondents in each age group engaging in each activity.*

Respondents were asked to provide their perception of water quality at the beach they reported visiting the most (Figure 3.6.). The most frequently visited beaches were Lamlash (28%), Whiting Bay (19%), Blackwaterfoot (14%), and Brodick (13%).

Overall, most respondents evaluated water quality as ‘Good’ or ‘Excellent’, although differences were noted across locations. Lamlash was rated ‘Excellent’ by only ~ 10% of users, with ~ 41% selecting ‘Good’; however, a combined ~ 48% selected ‘Sufficient’, ‘Poor’, or ‘Don’t Know’. Similarly, Whiting Bay received ~ 10% ‘Excellent’ ratings, whilst ~ 32% selected both ‘Good’ and ‘Sufficient’; ~ 26% were unsure about the ratings.

In contrast, Sannox and Kildonan show positive perceptions, with ~ 66.7% and 50% ‘Excellent’ responses respectively. Pirnmill and Kilmory also received positive ratings. On the other hand, however, Lochranza received a 100% ‘Poor’ rating, and Brodick had ~ 38% rating of ‘Good’ but also ~ 38% rating the water quality as only ‘Sufficient’.

The results suggest a generally positive perception of water quality across the Isle of Arran beaches; certain beaches (e.g., Lamlash, Whiting Bay, and Brodick) are associated with a more mixed/uncertain view. This might reflect local environmental issues, individual experiences, or a lack of public monitoring data availability.

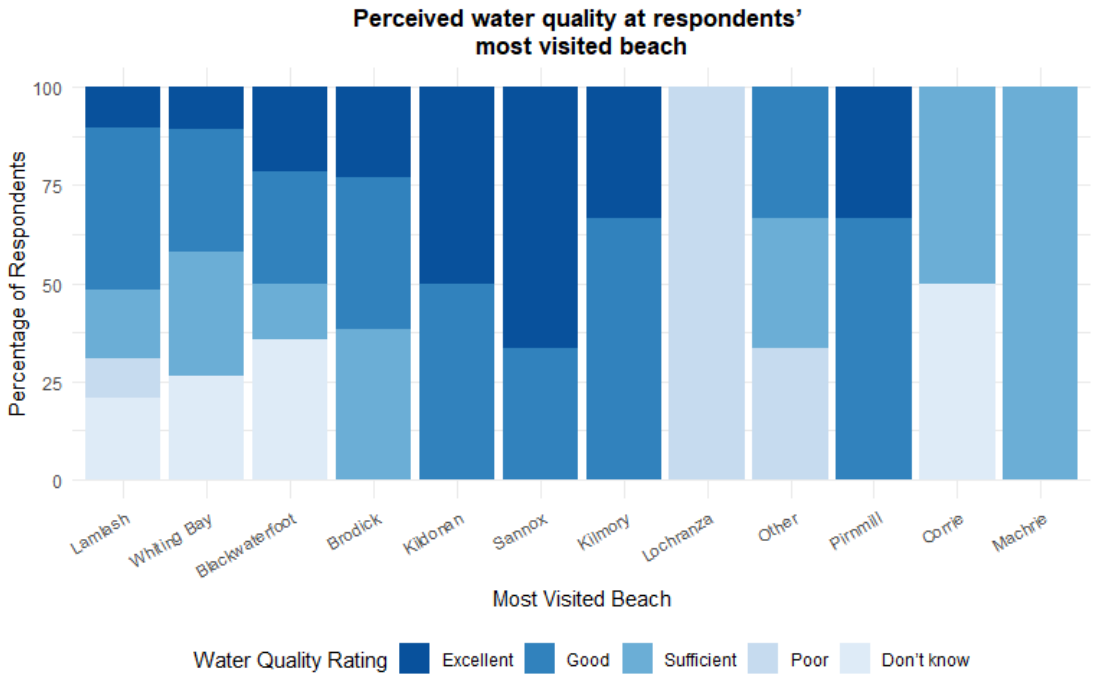

Figure 3.6. *Perceived water quality at respondents' most frequently visited beach, presented as percentage of total responses per beach. Beaches are ordered left to right by number of total responses, from Lamlash (n = 29) to Machrie (n = 1).*

A statistically significant association was found between beach visited most frequently and perceived water quality rating ($\chi^2 = 88.90$, df = 44, $p < 0.001$), Cramer's V was 0.467, indicating a very strong association between variables - supporting our finding suggesting some beaches are rated more positively than others, and are linked to localised perceptions.

In contrast, no significant association was found between the beach visited and avoidance of swimming due to water quality concerns ($p > 0.05$). While some patterns may be present, differences in avoidance behaviour were not statistically meaningful.

When investigating if respondents' perception of water quality at their most visited beach was associated with their likelihood of avoiding swimming due to water quality concerns, a significant association was found ($p = 0.002$), with a very strong effect ($V = 0.305$). Respondents who rated water quality as 'Poor', 'Sufficient', or 'Don't Know' were more likely to report

avoiding swimming, whereas those with more positive ratings were likely to disagree with the avoidance statement, suggesting a clear behavioural link between perceptions of water quality and recreational decisions - this supports the idea that water quality perceptions influence beach use.

3.5. Awareness of Existing Water Quality Management Strategies

Survey participants were asked questions regarding perceived benefits and economic impacts of water (Figure 3.7.). When asked whether designated bathing water status would bring wider benefits to the local communities, most respondents agreed (43%), and 36% strongly agreed, totalling 80% support. Only 8% disagreed or strongly disagreed. Suggesting a strong desire for formal bathing water designation. Similarly, responses to a question asking whether water quality impacts local industries (e.g., tourism, fisheries, or hospitality) showed majority agreement (62% total agreement). Only 16% disagreed, suggesting respondents generally perceive water quality as having important economic consequences, reinforcing the need for quality improvements for health and socioeconomic sustainability.

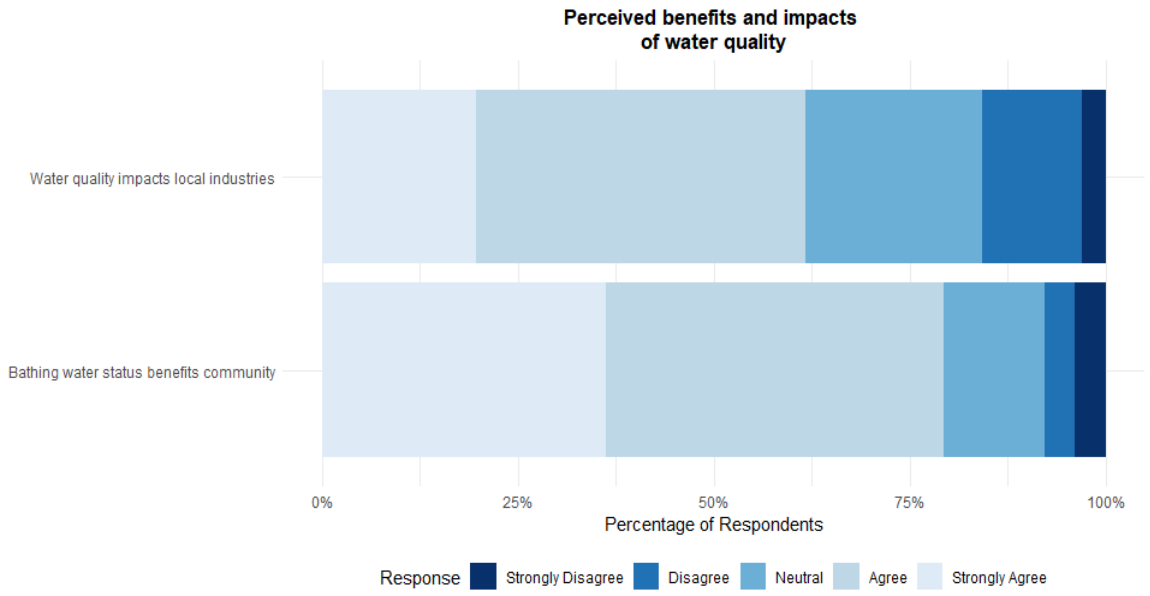

Figure 3.7. *Respondents' agreement with statements regarding the broader benefits and economic impacts of water quality. Values represent percentage of total responses. Questions included: "Designated bathing water status would bring wider benefits to local communities on Arran," and "Do you think water quality at the beach impacts local industries negatively?"*

There were no statistically significant associations between residency status and perceived community benefits of designated bathing water status ($p = 0.774$), nor between age group and agreement that water quality impacts local industries ($p = 0.515$). These results suggest broad, consistent views across demographic groups.

Respondents answered four questions pertaining to water quality management awareness and effectiveness (Figure 3.8.). Overall, 102 responses were gathered. First, when asked whether sufficient information is present at their most frequented beach, the results were largely skewed negatively. In total, 42% strongly disagreed and 41% disagreed, while only 5% agreed, with no participant strongly agreeing. Then, when asked if participants are aware of the role of organisations and local authorities, most respondents disagreed again (43%), with just 15% agreeing (including 5% strongly agreeing). In addition, over half (52%) of respondents do not

know how to find out about water quality at Arran's beaches, 27% strongly disagreed, and only 7% agreed/strongly agreed.

Lastly, respondents do not believe current water quality management measures are effective. With 43% selecting 'Neutral', and 46% disagreeing/strongly disagreeing. These results suggest a lack of public awareness and confidence in current water quality management/communication efforts. Consistently high disagreement rates highlight the need for greater visibility, clarity, and public engagement in coastal water management around the Isle of Arran.

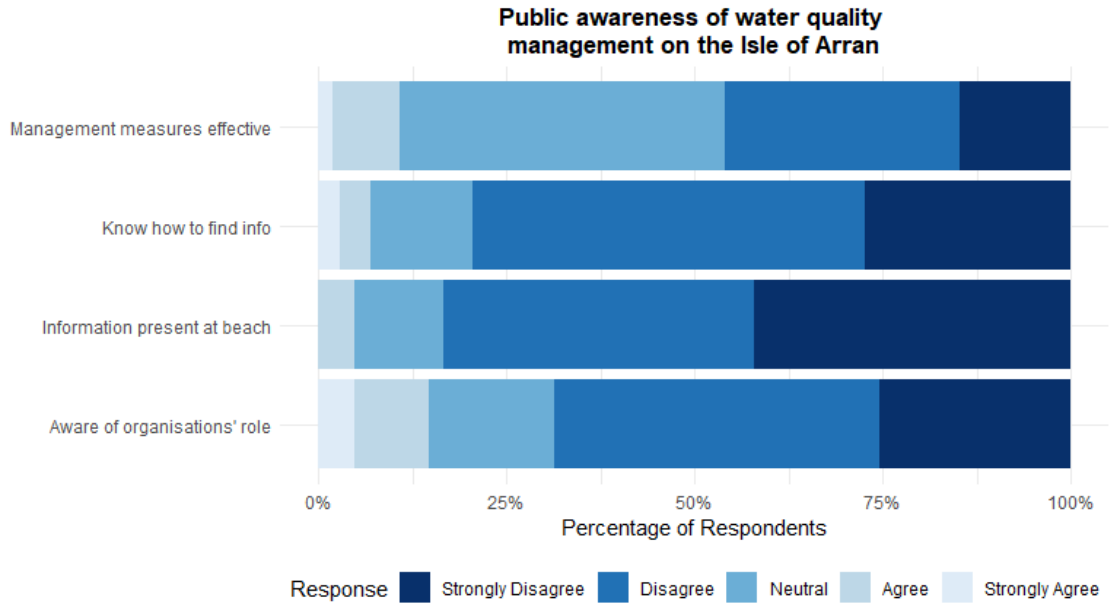

Figure 3.8. *Respondent agreement with statements about awareness and availability of water quality information and management on Arran. Results are displayed as a percentage of total responses to four statements related to information access, organisational roles, and effectiveness of management measures.*

There were no statistically significant associations between residency status and perceptions of information availability at beaches, nor between age group and awareness of the roles of local authorities in managing water quality. Similarly, knowledge of how to access water quality

information did not differ by residency status, and belief in the effectiveness of current management strategies did not vary significantly by age group (all $p > 0.05$). These results suggest a consistent pattern of low awareness, limited trust, and a general communication gap across demographic groups.

Table 3.3. *Summary of key themes and example quotes from suggestions for water quality improvement.*

Theme	Description	Example Quotes
Regular Monitoring & Reporting	Calls for more frequent water testing, data collection, and public reporting of results.	"Frequent monitoring at main beaches… ensuring the results are easily available to view." "Prosecutions for water quality infringements."
Transparency & Public Awareness	Suggestions for clearer communication about water quality issues and how to access information.	"More public awareness when issues arise." "Need greater visibility and proactive feedback."
Sewage & Septic System Improvements	Mentions of improving septic tanks, preventing sewage discharge, or enhancing treatment systems.	"Proper maintenance of sea outlets from private properties." "Better sewage treatment and septic tank repair."
Opposition to Fish Farms	Criticism of fish farming practices, especially in Lamlash Bay, and calls for bans or regulation.	"No more fish farms. Independent monitoring of fish farm." "Closure of the fish farm."

Theme	Description	Example Quotes
Signage & Beach Information	Requests for signage about reporting pollution and informing beach users of water status.	"Signage should be in place telling people how to report incidents." "Coloured flag status?"
Designated Bathing Water Status	Support for registering beaches for designated bathing status to enable formal monitoring.	"Getting the beaches registered… to measure bathing water status."
Ecosystem Restoration / Long-term Action	Broader suggestions about marine protection, policy enforcement, or reintroducing fishing limits.	"We need an ecosystem approach covering all aspects." "Return of the 3 mile limit."
No Suggestions or See No Problem	Responses indicating no issue, limited knowledge, or no suggestions offered.	"Really not bothered about it." "No improvement or monitoring needed."

Respondents were asked to provide open-ended suggestions for water quality management improvements. 45 responses were gathered, and key themes were tabulated (Table 3.3.). The most commonly mentioned need was for regular water quality monitoring, also accompanied by public reporting and transparent publication of the results. Users highlighted a lack of signage, calling for accessible information at beaches and/or online.

Major concerns for sewage management were noted, including better septic tank regulation, treatment infrastructure improvements, and stricter discharge enforcement. A significant number of respondents expressed opposition to fish farming, particularly in Lamlash Bay, citing pollution concerns, requesting closures or stronger regulations.

Comments supported implementation of designated bathing water status, in addition to long-term ecosystem restoration efforts, e.g., extending marine protected areas, or reintroducing 3-mile offshore fishing limits. Few participants saw no major issue or felt unable to contribute recommendations.

4. Discussion

4.1. Representativeness / Overview of Respondents

A total of 102 people participated in the online survey. Although a relatively small sample was gathered, the results provide valuable insights into the resident and visitor perspectives on water quality around the Isle of Arran. The demographic profile of respondents included a mix of residents, visitors, and some others with connections to the island. The distribution aligns with the study's intent to capture both local and outside points of view, as Arran's beaches are frequented by year-round inhabitants and seasonal tourists.

The predominance of older respondents aligns with Arran's ageing population (North Ayrshire Community Planning Partnership, 2017) - projections in the report suggest a continuing shift toward an ageing population, expected to comprise 50% of the island's population by 2026 - but may also reflect broader trends in environmental survey engagement. Older individuals are often more likely to participate in community and conservation-related research, potentially due to greater time availability or a stronger sense of environmental stewardship (Hawkins et al., 2016; Jones et al., 2024).

In terms of gender, greater female representation was recorded and is a common theme in environmental surveys. This imbalance may reflect a tendency for women to engage more readily with surveys (e.g., Jones et al., 2024; Oliver et al., 2023).

Employment data further reinforces the contextual fit of the data, with responses dominated by either full-time workers or retired individuals, suggesting a largely economically active or post-retirement population. This matches Arran's demographic shift toward older, less economically active communities (North Ayrshire Community Planning Partnership, 2017) and may also influence which environmental concerns take priority.

When asked to identify their most frequently visited beaches, participants predominantly selected Lamlash, Whiting Bay, Blackwaterfoot, and Brodick. These beaches are not only among the most developed on the island but are also located near key settlements and ferry terminals. This supports wider findings that beach visitation is often influenced by accessibility, infrastructure, and proximity to population centres (Gray et al., 2023). These patterns may help explain where perceptions of water quality are most acutely formed – at beaches that are most visible and most frequently used.

Ultimately, while the sample size limits generalisability of the results, the demographic characteristics observed broadly reflect the known population and usage patterns seen on Arran, supporting the relevancy and contextual fit of the following findings discussed.

4.2. Public Perception of Water Quality

The survey reveals clear trends in how beach users at Arran perceive coastal water quality. The majority of users consider water quality to be an important factor influencing their recreational experience. These findings are in line with previous research suggesting that perceived water cleanliness has close ties to aesthetic value and perceived health risks (Moser, 1984; Quilliam et al., 2019; Börger et al., 2021). These qualities are pivotal in user experiences of Arran's coastal blue spaces (Curtis et al., 2017; Jones et al., 2018).

However, perceptions of safety varied. While some participants expressed concern about water quality when swimming, others appeared less influenced. The variation highlights that individuals' assessments of environmental risk are context-dependent (Oliver et al., 2023; Leonard et al., 2020). While the beach may still be visited for other activities (e.g., dog walking, socialising), swimming is more directly linked to contact with water, and thus direct exposure to pollution can have a greater influence on perception (Börger et al., 2021).

When asked about the broader environmental concerns, a large proportion of participants expressed concern about the long-term impacts of water quality on the marine environment around Arran. This result suggests that many individuals' perspectives go far beyond personal risk and incorporate environmental values. This may reflect the positive influence of environmental organisations (e.g., COAST). In recent years, the UK has seen a surge in attention to sewage overflows and storm discharge events, prompting increased scrutiny of the water industry and its practices (Ford et al., 2025; Hawkins et al., 2016; Miguel et al., 2024). These narratives may influence the public's perceptions even in the absence of local data.

In contrast, only a small proportion of respondents agreed that water quality improved in the past five years, with most unsure. This uncertainty is likely linked to a lack of publicly accessible data on Arran’s coastal water quality. The island is not currently designated for bathing waters; therefore, it is excluded from regular SEPA (Scottish Environment Protection Agency) monitoring, meaning residents and visitors rely on visual cues, local knowledge, or media reports to assess safety of coastal waters for recreational use (Quilliam et al., 2019; Nabout et al., 2016; Nelson, 1998; Pendleton et al., 2001).

While most perceptions of water quality did not differ significantly by age or residency status, responses to the question of whether water quality had improved over the past five years did.

Residents were more likely to disagree that water quality had improved, while visitors tended to choose neutral or uncertain responses. This difference likely stems from residents' greater exposure to local beaches over time, giving them a more informed perspective on water quality changes. Local familiarity and frequent engagement with an environment can strengthen individuals' confidence in recognising environmental trends (Roca et al., 2009; Seenath et al., 2025).

The finding is reinforced in the open-text response, many participants raised specific concerns about raw sewage discharge, septic tank failures, and fish farming pollution, particularly in Brodick, Lamlash, and Lochranza. Accounts often included descriptions of foul odours, discoloured waters, visible sources of pollution, alongside frustration over the absence of signage or official communication during known contamination events. Notably, such concerns were more commonly reported by residents than by visitors, potentially reflecting greater exposure to local conditions and a deeper sense of place-based knowledge (Mulvaney et al., 2020). These accounts add depth to the Likert results, reinforcing the concerns that, in the absence or unawareness of any formal monitoring, people often rely on individual empirical observations or community reports when forming their perceptions about water quality (Shepherd, 2014; Quilliam et al., 2019; Oliver et al., 2016; Moser, 1984).

These findings suggest that when individuals care about a place and lack clear information about environmental risks, they are highly likely to rely on personal and collective experiences to assess potential risks. This creates opportunities for improving water quality policy and communication strategies, as strong public concern can motivate action (Tran et al., 2002); however, uncertainty and anecdotal knowledge can lead to a misperception and trust challenge (Shahbazi and Bunker, 2024; Pendleton et al., 2001).

Ultimately, the results suggest that water quality is a salient concern for beach users on Arran, and this concern is shown in both experiential and environmental values of residents and visitors. A strong consensus that water quality matters exists; however, the perceived direction of change is unknown due primarily to the absence of visible management or published data.

4.3. Sources of Perception and Awareness

Understanding how individuals form their perceptions of water quality is essential for informing effective environmental communication and subsequent management strategies (Marx et al., 2007; Tran et al., 2002). The results explored the origins of individual perceptions and how public awareness of water quality issues, monitoring, as well as governance can shape human behaviours.

Participants were asked to expand on their general perceptions of water quality, revealing a rich mix of first-hand observations, anecdotes, and general environmental awareness. Many described visible signs of pollution (e.g., discoloured water, plastic debris, smell of sewage), often linked with specific locations, including Lochranza and Lamlash Bay. These individual, place-based experiences often serve as informal indicators of water quality, especially when access to real-time or official data is limited (Shepherd, 2014; Altman et al., 2023). Others referenced local incidents such as known sewage leaks, frustrations with a lack of warning signage, or uncertainty about where to access real-time water quality data. All of these narratives underline the importance of experiential knowledge (Marx et al., 2007) - personal/community experiences act as key sources of information in informing perceptions when formal data is absent (Shahady and Boniface, 2018; Morgan, 1999).

Participants' views on the causes of declining water quality revealed a broad environmental awareness, with many demonstrating familiarity with both land- and marine-based pollution

sources. Microplastics, sewage, agricultural runoff, fish farming, and petrochemical discharge were frequently selected as perceived contributors. This suggests Arran's beach users hold relatively informed views, likely shaped by a mixture of personal observations, local conversations, and growing media attention on marine degradation (Shepherd, 2014; Altman et al., 2023; Omoyajowo et al., 2022). Interestingly, while microplastics were among the most commonly selected contributors overall, when respondents were asked to identify the single most important cause of degradation, nearly half pointed to faecal contamination from sewage and farming. This shift may reflect deeper concerns for risks with immediate implications for human health and coastal recreation, especially given the visual, olfactory, and experiential nature of sewage pollution (Seymour et al., 2025; Rangel-Buitrago et al., 2024). Recent public discourse and media scrutiny around sewage discharges into English coastal waters may also be amplifying public concerns around microbial pollution (Ford et al., 2025). The pattern in these results points to awareness of pollution in various forms, but also a priority in the threat most perceived as hazardous to beach use and individual experience.

Despite high levels of concern, limited awareness of how water quality is currently monitored and managed was demonstrated. Many reported not having seen any signage or informational displays at their most frequently visited beaches, felt unclear about the roles of local authorities, and were unsure how to access quality reports or evaluate the effectiveness of existing strategies. This consistent pattern of disconnection reflects a broader issue identified in literature: public interest in environmental issues does not always translate into awareness of the actual institutional processes or access to actionable information (Altman et al., 2023; Shepherd, 2014), engaged communities often feel excluded from decision-making or uninformed about governance systems (Hawkins et al., 2016). Improving signage, investing in digital

communication tools, and developing targeted outreach strategies can help address this gap, particularly in settings like Arran, where formal monitoring infrastructure is limited (Quilliam et al., 2019).

Awareness gaps regarding water quality monitoring were consistent across demographic groups, including age and residency status. This uniformity of responses challenges the assumption that residents, due to their proximity and potential engagement with local environmental issues, would possess greater awareness of monitoring efforts, as residents often exhibit strong environmental concern and place attachment (Zhang et al., 2014). However, this does not always translate to heightened awareness of formal governance or monitoring activities. The findings underscore that public communication about water quality on Arran is limited or ineffective in general. Qualitative responses also support this finding with frustrated responses or uncertainty about which agencies are responsible, “a lack of official presence”, “no signage”.

The preliminary thematic analysis of suggestions for improvement reinforces this same pattern. A substantial number of users called for more regular monitoring and transparency of results, as well as better signage and communication tools (Shepherd, 2014). There were many individuals interested in seeing real-time or regularly updated data, with references to national efforts (e.g., The Safer Seas & Rivers Service, ran by Surfers Against Sewage), asking for pollutant data to be published around the coast by Scottish Water. Other participants emphasised the importance of COAST as a local advocate, with some wrong assumptions that the organisation conducts formal water quality monitoring. The results reflect trust in local actors but frustration with institutional gaps, creating opportunities and challenges for future water quality communication and management (Altman et al., 2023; Pascaline, 2025).

Ultimately, the results indicate that while beach users on Arran demonstrate considerable environmental awareness, individual perceptions are built on observation rather than evidence. Limited access to official information and a shared desire for clearer, localised communication were evident. This underscores the importance of establishing transparent, visible, and community-centred water quality governance that bridges the gap between public perception and policy-led management (Vaz et al., 2009).

4.4. Beach Usage and the Behavioural Influence of Water Quality

Understanding the influence of water quality on beach usage is fundamental for evaluating the real-world implications of environmental degradation of coastal waters (Börger et al., 2021). Insights on Arran's most frequented beaches and recreational benefits/use, and how water quality affects behaviours, allowed for thorough investigations.

Responses indicate that coastal spaces are widely used and highly valued by the public for a range of recreational purposes, with Lamlash, Whiting Bay, Blackwaterfoot, and Brodick emerging as the most frequently visited. The popularity of these beaches aligns with locality profiles, which confirm the survey captured views related to Arran's key recreational hubs (North Ayrshire Community Planning Partnership, 2017).

In terms of activity, 'Walking or dog-walking', 'Relaxation/scenery', and 'Swimming/bathing' were among the most frequently selected activities across all age demographics. However, some nuanced trends were revealed upon stratification. For instance, walking and relaxation were more prominent in older individuals, while younger people tended to select swimming, diving, or wildlife watching. Family activities and walking showed statistically significant associations with age, meaning life stage may shape individuals' engagement with coastal spaces (Colley et al., 2019). The diversity of responses across all age groups reinforces just how important Arran's

beaches are as multi-functional spaces supporting both the physical and passive wellbeing of users (Börger et al., 2021; Morgan, 1999; Oliver et al., 2023).

When identifying the most important benefit gained from visiting beaches, mental wellbeing emerged as the dominant theme across all age groups. This aligns with growing recognition that natural coastal environments offer restorative experiences, through conservation or recreation, that support psychological health (Cox et al., 2004; Pichler et al., 2025). The preference for mental wellbeing, such as feeling calm, escape, or emotional clarity, remains high among younger and older respondents, potentially reflecting increased public awareness of nature-based wellbeing and the mental health benefits of blue spaces (White et al., 2020; Oliver et al., 2023). Exposure to coastal environments can reduce stress, promote mindfulness, and enhance mood regulation, especially when users have strong emotional or cultural connections to a place (Börger et al., 2021). Physical exercise was consistently the second most valued benefit, reinforcing the dual role of beaches in supporting mental and physical health. In contrast, social connection was rarely selected as having the greatest importance/benefit, suggesting an introspective preference for beach usage rather than a primarily social one.

Interestingly, although most people visited beaches regularly and associated them with positive outcomes, willingness to enter water appeared to be contingent on individual perceived water safety. When asked if users ever decided not to swim due to water quality concerns, responses were a mixed-bag; these results suggest water quality may not deter visits entirely but influences how they engage with the environment, particularly when it comes to activities that involve direct contact with the water.

Additional insights came from the question asking users to rate water quality at their most frequently visited beach. Beaches such as Pirnmill, Kildonan, and Sannox were rated more

positively, while Brodick and Lamlash received more ‘Sufficient’ or ‘Poor’ ratings, alongside a higher proportion of unsure responses. These patterns correspond closely with respondents’ reported avoidance of swimming, reinforcing the idea that perceptions of water cleanliness play a key role in shaping behaviour. Rather than abandoning beaches entirely, individuals appear to adapt their usage, choosing passive or observational activities, such as walking or relaxing, when water is perceived as unsafe, which supports the view that water quality perceptions directly influence swimming decisions (Leonard et al., 2020; Oliver et al., 2023).

Furthermore, these results provide clear evidence that while beach users continue to value and frequent Arran’s beaches, their engagement behaviours may shift in response to perceived environmental risks (Figure 1.2.). This decision-making framework underscores the important distinction between visitation and actual immersion, as people may still walk, relax, or socialise at perceived polluted beaches, but water-based recreation is less likely. The model provides a valuable roadmap for understanding how individuals assess environmental cues, such as visible pollution or trusted information sources, and ultimately decide whether to engage in water-based recreation. For policymakers and regulators, applying this framework could help understand beach usage patterns, tailor public health messaging, and improve access to trustworthy water quality information at the point of decision.

These behavioural shifts can have implications for public health promotion and environmental communication. Given the growing recognition of blue spaces as being valuable for wellbeing (Oliver et al., 2023), ensuring confidence about water quality is vital for enabling full access to beach benefits. Moreover, perceived water safety likely will become more critical as Arran’s wild swimming, paddleboarding, and open-water events continue to grow in popularity (VisitArran, 2025).

To summarise, the data gathered supports Arran's beaches being multi-functional spaces deeply embedded in personal wellbeing for users. Water quality does not appear to deter general beach use; however, it affects the types of activities residents and visitors undertake, particularly swimming. This underlines a need for transparent, localised water quality information to enable informed decision-making and support continued recreational use of these coastal environments in both safe and emotionally restorative ways.

4.5. Support for Management Measures and Perceived Economic Impacts

The survey explored the extent to which beach-users support existing or potential water quality management efforts and their perceptions on the economic impacts of water quality on Arran's industries. Across both closed and open-ended questions, clear evidence of concern, interest in regulation, and desire for greater transparency and accountability exists. This builds on the decision-making framework conceptualised in Figure 1.2., which could be used by decision-makers to explore improvements in beach usage both in Arran and further afield.

When asked whether the designation of Arran's beaches as official bathing waters would bring wider community benefits, an overwhelming majority of respondents agreed, while very few expressed disagreements. This reflects a strong public perception that official designation could enhance not only health protections but also deliver broader socioeconomic value. Designation offers mechanisms for routine monitoring, improved environmental visibility, and can elevate the island's reputation as a clean and safe destination for recreation and tourism (Börger et al., 2021). Moreover, designated bathing waters can act as focal points for aligning public health protection with ecosystem service provision, reinforcing their value for Arran's communities (Quilliam et al., 2015). However, designations introduce trade-offs, particularly a challenge of

balancing public health requirements with ecosystem service protection (Quilliam et al., 2015). Thus, managing these tensions is key to ensuring the designation meets both environmental and community expectations on Arran.

High levels of concern about the potential impact of poor water quality on Arran's industries, particularly tourism, fisheries, and hospitality, reflect a strong public awareness of the link between environmental quality and economic sustainability (Russ et al., 2022). In tourism-dependent areas like Arran, even the perception of pollution can damage reputation and affect visitor numbers (Börger et al., 2021; Martínez-Gomariz et al., 2021). Deterioration in water quality can lead to measurable declines in recreational use (Vesterinen et al., 2010), underscoring the importance of public health and environmental stewardship in maintaining long-term economic resilience. Seasonal strain on infrastructure and media/community reports of sewage discharge likely heightens these sensitivities among Arran's beach users (Ford et al., 2025; Lichtmannegger et al., 2024).

Strong expressions of concern arose consistently across age groups and residency status, with no significant associations identified. The consistency suggests shared belief in water quality importance. Regardless of demographic background, the issue transcends social divisions, reinforcing the idea that clean water is viewed collectively as a resource of community concern (Marin, 2009).

The open-ended suggestions provided by participants offer valuable insight into public expectations for more proactive and transparent water quality governance. Calls for improved monitoring, seasonal sampling, and accessible reporting platforms (e.g., signage or digital dashboards) suggest many users not only desire more water quality data but also want it to be timely, visible, and easy to understand. Clear, real-time information provision increases public

trust and response (Pascaline, 2025). There is demand for technical management and communicative accountability, i.e., environmental agencies and utilities making information available and actionable to Arran's public (Ford et al., 2025). Integrating Arran into national tracking systems is emphasised, e.g., SEPA's monitoring network, or the Safer Seas and Rivers Service (SSRS), reflecting the public's desire for monitoring across the coast and frustrations with the island's current exclusion from the Bathing Water Directive. Suggestions for tighter regulations of aquaculture and the enforcement of septic tank maintenance reveal deep concerns regarding systemic sources of pollution and perceived lack of official control. Public education campaigns and eco-accreditation schemes, such as Blue Flag awards, may further increase awareness and pride, to consequently drive public environmental stewardship (Hartley et al., 2015; Liman and Ibrahim, 2025; Dobrzycka-Krahel and Fidalgo, 2025; Tran et al., 2002). The responses indicate that beach users are not only concerned but also engaged and willing to propose solutions. This reflects a trust in local stewardship but also gaps in communication regarding who holds responsibility and the systems in place (Altman et al., 2023).

Overall, the public is not passive in their concern for coastal water quality. Instead, clear evidence supports stronger management, better regulation, and community-inclusive approaches (Shahady and Boniface, 2018). These findings provide a valuable foundation for future water quality designation proposals, efforts would be welcomed and supported by both residents and visitors of Arran.

4.6. Limitations and Future Research Directions

While this study offers important insights into public perceptions, beach-usage patterns, and awareness of water quality issues on the Isle of Arran, several limitations must be acknowledged when interpreting the aforementioned findings.

First, the survey sample size is relatively small, with 102 participants completing the survey. This limits the generalisability of statistical findings and may not fully reflect the diverse views held across resident and visitor populations. Moreover, a clear gender imbalance was prevalent. While this may reflect known trends in survey engagement or environmental participation, it restricts the ability of the survey to explore gender-based differences in perceptions and behaviours. Within the cost and resource constraints of the project, the sample does highlight findings that should be pursued further with follow-up investigation.

In addition, the survey was administered exclusively online, introducing selection bias. Those without reliable internet access, particularly older residents or less digitally engaged tourists, may have been underrepresented in the study. Similarly, individuals already connected to COAST's networks or environmental forums may be more inclined to respond, resulting in a sample more environmentally engaged/informed than Arran's general public. To mitigate this in future research, combining online distribution, paper-based surveys, in-person interviews, and distribution at key public locations (e.g., ferry terminals, community centres, or local events) can broaden outreach, ensuring a more diverse and representative sample of Arran's population and visitor base.

Another limitation is the reliance on self-reported perception data, which is valuable but might not always reflect actual water quality conditions. Respondents often base their views on visual cues, anecdotal evidence, or online information. Therefore, in the absence of formal water quality monitoring on Arran, there is no real benchmark for validation. Furthermore, while open-ended responses provide rich qualitative insights, thematic categorisation relies on subjective interpretations, which, despite public efforts to ensure rigour, remains potentially a source of bias (Fleisher and Kay, 2006).

Future research benefits from a larger, more representative sample, including offline recruitment methods to reach a broader audience (e.g., in-person beach interviews). Given that the survey was conducted during the off-season (November to January), when visitor numbers are at their lowest, it would be valuable to conduct additional seasonal surveys to capture changes in perception and usage during peak months, as over half of annual visits tend to occur between May and September (Tipler A, 2023; VisitArran, 2024). Most critically, linking perception data with formal water quality measurements could provide a stronger basis for identifying mismatches, misconceptions, or emerging concerns (Marin, 2009). Challenging, but beneficial, longitudinal studies can further reveal how public awareness and trust evolve temporally in response to management interventions, new data availability, or environmental change (Gao et al., 2018).

5. Conclusion

Coastal water quality is central to public wellbeing and environmental health, particularly on islands like Arran, where beach use plays a vital role in community identity and tourism (Gray et al., 2023; North Ayrshire Community Planning Partnership, 2017). This study highlights how perceptions of water quality influence recreational behaviour and ultimately shape public trust in environmental governance.

Beyond reaffirming the value of clean coastal environments, findings signal a critical need for stronger communication strategies, routine monitoring, and visible, accessible data (Quilliam et al., 2019). Public support for designated bathing water status and transparent water quality reporting reflects both concern and a readiness to engage in solutions. These insights point to a significant opportunity on Arran for collaborative governance, i.e., leveraging community trust in local organisations while enhancing institutional accountability.

The decision-making framework outlined in Figure 1.2. offers a useful model for understanding how users navigate water quality uncertainty, particularly when deciding whether to engage in activities involving direct water contact. As pressures on coastal environments grow, such frameworks can help guide public health messaging, signage, and digital tools to support safe and confident beach use.

Looking ahead, future research must explore the integration of citizen science, digital communication tools, and seasonal variations in water use and public perception (Ramírez et al., 2023). On a practical level, there is a growing necessity to ensure Arran is included in national monitoring frameworks, and for data to be communicated in ways that empower beach users. With coastal pressures increasing, supporting informed and engaged communities is key to safeguarding both the ecological integrity and wellbeing derived from Scottish blue spaces.

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7. Appendices

7.1. Survey Questions

Table 7.1. *Online survey questions. The list of questions (n=27) includes single-choice, multiple-choice, Likert-scale, and open-ended responses. Questions (Qn) were asked to gather views on the user (Q1-4); beaches visited and main influences on visit frequency and beach usage (Q5-10); perceptions of current water quality at these locations and what information or experiences have informed those views (Q11-22); and the views and level of awareness about existing water quality management measures (Q23-27).*

Questions	**Answers**
1. What is your Age	Multiple Choice

	• 18-24 • 25-34 • 35-44 • 45-54 • 55-64 • 65+
2. Resident on Arran or Visitor	Multiple Choice • Resident • Visitor • Other (please specify)
3. Gender	Multiple Choice • Male • Female • Non-binary • Prefer to self-describe • Prefer not to say
4. Employment Status	Multiple Choice • Full-Time • Part-Time • Student • Unemployed

	• Retired • Prefer not to say
5. Please identify all the following beaches on Arran that you visit regularly.	Multiple Choice (*choose multiple*) • Blackwaterfoot • Brodick • Corrie • Kildonan • Kilmory • Lamlash • Lochranza • Machrie • Pirnmill • Sannox • Whiting Bay • Other (please specify)
6. Please identify the beach that you visit the most overall.	Multiple Choice (*choose one*) • Blackwaterfoot • Brodick • Corrie • Kildonan • Kilmory

	• Lamlash • Lochranza • Machrie • Pirnmill • Sannox • Whiting Bay • Other (please specify)
7. How often do you visit Arran's beaches?	Multiple Choice *(choose one)* • Daily • Weekly • Monthly • Yearly • Rarely
8. What activities do you most regularly undertake when visiting Arran's beaches (up to three responses max).	Multiple Choice (*choose top 3*) • Swimming / Bathing • Relaxation / Scenery • Family Activities • Craft-based Water Sports • Walking/dog walking • Diving/ snorkelling • Wildlife watching

	• Other (please specify)				
9. What benefit(s) do you gain from a visit to the beach, in your opinion?	Multiple Choice (*choose all that apply*) • Physical (Exercise, recreation) • Social (Friends & Family) • Mental (i.e., Engaging with nature) • Other (please specify)				
10. What is the most important benefit to you from a visit to the beach?	Multiple Choice (*choose one*) • Physical (Exercise, recreation) • Social (Friends & Family) • Mental (i.e., Engaging with nature) • Other (please specify)				
Please read the following statements and record your level of agreement: Scale of strongly disagree, disagree, neutral, agree, strongly agree.	SD	D	N	A	SA
11. Coastal water quality impacts on my enjoyment of my visit to the beach					
12. Water quality will influence my decision of which beach to visit					

13. There have been times when I have decided not to swim in the sea around Arran due to the water quality concerns					
14. I am concerned about the long-term impacts of water quality on the marine environment around Arran					
15. The water quality at beaches around Arran has improved over the last 5 years					
16. Please expand on the reasoning for your previous answers relating to your general perceptions of water quality at Arran's beaches.	Open ended				
	SD	D	N	A	SA
Bathing water status indicates water quality at designated bathing sites, assessed for health risks and pollution. Classified as excellent, good, sufficient, or poor. The beaches on Arran are not currently monitored or designated as bathing waters.					

17. I would support the monitoring of bathing water quality at beaches on Arran					
18. Thinking of the beach you visit most regularly on Arran, how would you rate its water quality?	Multiple choice (*choose one*) • Excellent, • Good • Sufficient • Poor • Don't know				
19. Please identify all of the issue(s) you believe impact on water quality at Arran's beaches?	Multiple (*choose multiple*) • Faecal Bacteria from land-based human sewage sources and farming • Nutrient runoff from farming, forestry or other land-based activities • Nutrient and chemical inputs from aquaculture • Sediment from field, forestry and road runoff				

	• Faecal bacteria from sewage discharges from marine craft • Petrochemical discharges and residue from ships and boats • Microplastic particles resulting from breakdown of waste plastic • Other (please specify)
20. Which of the following do you believe to be the greatest issue for water quality at your most frequently visited beach?	Multiple (*choose one*) • Faecal Bacteria from land-based human sewage sources and farming • Nutrient runoff from farming, forestry or other land-based activities • Nutrient and chemical inputs from aquaculture • Sediment from field, forestry and road runoff • Faecal bacteria from sewage discharges from marine craft • Petrochemical discharges and residue from ships and boats

	• Microplastic particles resulting from breakdown of waste plastic • Other (please specify)				
	SD	D	N	A	SA
21. Designated bathing water status would bring wider benefits to the local communities on Arran					
22. Do you think water quality at the beach impacts local industries negatively? (e.g., tourism, fisheries, hospitality)					
23. Sufficient information concerning water quality is present at the beach you visit most frequently					
24. I feel well informed about the role of organisations or local authorities in management and protection of Arran's water quality					
25. I know how to find out about the water quality at beaches around Arran					

26. Current water quality management measures on Arran are effective in tackling water quality issues					
27. Do you have any suggestions for the improvement of water quality and/or related management measures on Arran?	Open ended				

7.2. R Code for Analysis

Libraries Used:

1. **flextable** – for creating and formatting tables for Word output
2. **dplyr** – for data manipulation and transformation
3. **magick** – for image reading and editing (e.g. rotating images)
4. **tidyverse** – loads core packages like ggplot2, dplyr, tidyr, etc.
5. **ggplot2** – for creating data visualisations
6. **tidyr** – for reshaping and tidying data
7. **stringr** – for string manipulation
8. **vcd** – for computing association statistics like Cramer's V
9. **forcats** – for working with factors (used with Likert scale plotting)
10. **knitr** – for including graphics and rendering tables
11. **readr** – implicitly used via read_csv() from tidyverse

7.2.1. Data Preparation & Cleaning

Scripts for loading, cleaning, and transforming survey data to ensure consistency and readiness.

for analysis.

Example 1 – Loading and Cleaning the Data:

```
library(tidyverse)

Data <- read_csv("Data_Uncoded.csv") # Read csv file

colnames(Data)

data_clean <- Data %>%
  mutate(
    Respondent_ID = as.integer(Respondent_ID),

    # Q1-Q4
    Q1 = factor(Q1, levels = c("18-24", "25-34", "35-44", "45-54", "55-64", "
65+")),
    Q2 = factor(Q2),
    Q2.5 = as.character(Q2.5),  # "Other" response
    Q3 = factor(Q3),
    Q4 = factor(Q4),

    # Q5 - Multi-select
    Q5 = as.character(Q5),
    Q5.5 = as.character(Q5.5),

    # Q6 - Single select + Other
    Q6 = factor(Q6),
    Q6.5 = as.character(Q6.5),

    # Q7
    Q7 = factor(Q7, levels = c("Daily", "Weekly", "Monthly", "Yearly", "Rarel
y")),

    # Q8 - Multi-select
    Q8 = as.character(Q8),
    Q8.5 = as.character(Q8.5),

    # Q9 - Multi-select + Other
    Q9 = as.character(Q9),
    Q9.5 = as.character(Q9.5),

    # Q10 - Single select + Other
    Q10 = factor(Q10),
```

```
    Q10.5 = as.character(Q10.5),

    # Q11–Q15: Likert (ordered factors)
    Q11 = factor(Q11, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q12 = factor(Q12, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q13 = factor(Q13, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q14 = factor(Q14, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q15 = factor(Q15, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),

    # Q16 – Open-ended
    Q16 = as.character(Q16),

    # Q17–Q22
    Q17 = factor(Q17, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q18 = factor(Q18, levels = c("Excellent", "Good", "Sufficient", "Poor", "
Don’t know")),
    Q19 = as.character(Q19),
    Q19.5 = as.character(Q19.5),
    Q20 = factor(Q20),
    Q20.5 = as.character(Q20.5),
    Q21 = factor(Q21, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q22 = factor(Q22, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),

    # Q23–Q26
    Q23 = factor(Q23, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q24 = factor(Q24, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q25 = factor(Q25, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),
    Q26 = factor(Q26, levels = c("Strongly Disagree", "Disagree", "Neutral",
"Agree", "Strongly Agree"), ordered = TRUE),

    # Q27 – Open-ended
    Q27 = as.character(Q27)
  )
```

Example 2 – Splitting Multiple Selections:

```
# Split and tidy Q19 responses
q19_tidy <- data_clean %>%
```

```
  select(Q19) %>%
  filter(!is.na(Q19)) %>%
  mutate(Q19 = str_split(Q19, ",")) %>%  # Split on commas
  unnest(Q19) %>%
  mutate(Q19 = str_trim(Q19))            # Trim whitespace

q19_summary <- q19_tidy %>%
  group_by(Q19) %>%
  summarise(Count = n()) %>%
  arrange(desc(Count))
```

7.2.2. Plotting Figures for Results

Visualisation code used to display survey results, including bar plots and Likert scale distributions.

Example 1 – Most Important Benefit from Visiting the Beach by Age Category:

```
# Prepare the data
q10_age_plot <- data_clean %>%
  filter(!is.na(Q1), !is.na(Q10)) %>%
  count(Q1, Q10) %>%
  group_by(Q1) %>%
  mutate(Percentage = n / sum(n) * 100)

# Plot

ggplot(q10_age_plot, aes(x = Q1, y = Percentage, fill = Q10)) +
  geom_col(position = "dodge") +
  scale_fill_manual(values = c(
    "Mental (i.e., Engaging with nature)" = "#4292c6",
    "Physical (Exercise, recreation)" = "#2171b5",
    "Social (Friends & Family)" = "#08519c",
    "Other" = "#08306b"
  )) +
  labs(
    title = "Most Important Benefit from Visiting the Beach\nGrouped by Age C
ategory",
    x = "Age Group",
    y = "Percentage of Respondents",
    fill = "Benefit Type"
  ) +
  theme_minimal(base_size = 10) +
  theme(
    plot.title = element_text(face = "bold", hjust = 0.5),
    axis.text.x = element_text(angle = 0),
    legend.position = "bottom"
  )
```

Example 2 – Likert Responses to Water Quality:

```
# Questions to include
likert_questions <- c("Q23", "Q24", "Q25", "Q26")

# Clean and combine all 4 into one long dataframe
likert_data <- data_clean %>%
  select(all_of(likert_questions)) %>%
  pivot_longer(cols = everything(), names_to = "Question", values_to = "Respo
nse") %>%
  filter(!is.na(Response)) %>%
  mutate(
    Response = factor(Response, levels = c("Strongly Disagree", "Disagree", "
Neutral", "Agree", "Strongly Agree")),
    Question = recode(Question,
                      Q23 = "Information present at beach",
                      Q24 = "Aware of organisations' role",
                      Q25 = "Know how to find info",
                      Q26 = "Management measures effective")
  )

# Plot
ggplot(likert_data, aes(x = Question, fill = Response)) +
  geom_bar(position = "fill") +
  scale_y_continuous(labels = scales::percent) +
  scale_fill_manual(values = c(
    "Strongly Disagree" = "#08306b",
    "Disagree" = "#2171b5",
    "Neutral" = "#6baed6",
    "Agree" = "#bdd7e7",
    "Strongly Agree" = "#deebf7"
  )) +
  labs(
    title = "Public awareness of water quality \nmanagement on the Isle of Ar
ran",
    x = NULL,
    y = "Percentage of Respondents",
    fill = "Response"
  ) +
  coord_flip() +
  theme_minimal(base_size = 11) +
  theme(
    plot.title = element_text(face = "bold", hjust = 0.5, size = 13),
    legend.position = "bottom"
  )
```

7.2.3. Statistical Analyses (Chi-Squared Tests and Cramer's V)

Associations between variables (e.g., age group and concern levels) were tested using Chi-Squared tests and effect sizes with Cramer's V.

Example 1 – Chi-Square Test and Cramver's V (Q10 x Q1):

```
# Create percentage summary table
q10_age_summary <- data_clean %>%
  filter(!is.na(Q1), !is.na(Q10)) %>%
  count(Q1, Q10) %>%
  group_by(Q1) %>%
  mutate(Percentage = round(n / sum(n) * 100, 1)) %>%
  arrange(Q1, desc(Percentage))

# View the summary
q10_age_summary

library(dplyr)
library(vcd)

# Filter and tabulate the data
q10_q1_test_data <- data_clean %>%
  filter(!is.na(Q10), !is.na(Q1))

# Create contingency table
q10_q1_table <- table(q10_q1_test_data$Q10, q10_q1_test_data$Q1)

# Chi-squared test
q10_q1_chi <- chisq.test(q10_q1_table)
print(q10_q1_chi)

# Cramer's V
assocstats(q10_q1_table)
```

7.2.4. Table Generation

Summary tables were generated and formatted for reporting using the flextable package.

Example 1 – Respondent Demographics:

```
# Clean and summarise demographics
summary_table <- data_clean %>%
  select(
    Age = Q1,
    Residency = Q2,
```

```
    Gender = Q3,
    Employment = Q4
  ) %>%
  pivot_longer(cols = everything(), names_to = "Variable", values_to = "Respo
nse") %>%
  filter(!is.na(Response)) %>%
  group_by(Variable, Response) %>%
  summarise(Count = n(), .groups = "drop") %>%
  group_by(Variable) %>%
  mutate(Percentage = round(Count / sum(Count) * 100, 1)) %>%
  arrange(Variable, desc(Count)) %>%
  mutate(Value = paste0(Count, " (", Percentage, "%)")) %>%
  select(Variable, Response, Value) %>%
  pivot_wider(names_from = Variable, values_from = Value, values_fill = "-")

# Render as table
flextable(summary_table) %>%
  set_caption("Table 3.1. Summary of respondent demographics, including age,
residency, gender, and employment status.") %>%
  autofit()
```

Example 2 – Thematic Table from Open Responses:

```
# Create the Q27 table
q27_flex <- data.frame(
  Theme = c(
    "Regular Monitoring & Reporting",
    "Transparency & Public Awareness",
    "Sewage & Septic System Improvements",
    "Opposition to Fish Farms",
    "Signage & Beach Information",
    "Designated Bathing Water Status",
    "Ecosystem Restoration / Long-term Action",
    "No Suggestions or See No Problem"
  ),
  Description = c(
    "Calls for more frequent water testing, data collection, and public repor
ting of results.",
    "Suggestions for clearer communication about water quality issues and how
to access information.",
    "Mentions of improving septic tanks, preventing sewage discharge, or enha
ncing treatment systems.",
    "Criticism of fish farming practices, especially in Lamlash Bay, and call
s for bans or regulation.",
    "Requests for signage about reporting pollution and informing beach users
of water status.",
    "Support for registering beaches for designated bathing status to enable
formal monitoring.",
    "Broader suggestions about marine protection, policy enforcement, or rein
troducing fishing limits.",
```

```
    "Responses indicating no issue, limited knowledge, or no suggestions offe
red."
  ),
  Example_Quotes = c(
    "“Frequent monitoring at main beaches… ensuring the results are easily av
ailable to view.”\n“Prosecutions for water quality infringements.”",
    "“More public awareness when issues arise.”\n“Need greater visibility and
proactive feedback.”",
    "“Proper maintenance of sea outlets from private properties.”\n“Better se
wage treatment and septic tank repair.”",
    "“No more fish farms. Independent monitoring of fish farm.”\n“Closure of
the fish farm.”",
    "“Signage should be in place telling people how to report incidents.”\n“C
oloured flag status?”",
    "“Getting the beaches registered… to measure bathing water status.”",
    "“We need an ecosystem approach covering all aspects.”\n“Return of the 3
mile limit.”",
    "“Really not bothered about it.”\n“No improvement or monitoring needed.”"
  )
)

# Format the table for Word output
flextable(q27_flex) %>%
  set_caption("Table 3.3. Summary of key themes and example quotes from sugge
stions for water quality improvement.") %>%
  width(j = 1, width = 2) %>%
  width(j = 2, width = 3) %>%
  width(j = 3, width = 4.5) %>%
  align(align = "left", part = "all") %>%
  set_table_properties(width = 0.98, layout = "autofit")
```