Water Conservation and Consumption: The Role of Psychological and Social Factors

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Ph.D. Thesis on

Water Conservation and Consumption: The Role of Psychological and Social Factors

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Abstract

Promoting residential water conservation is essential to address water shortages caused by the rapidly increasing demand for water in both developed and developing countries. Understanding the key factors that influence water conservation efforts is essential because it can help implement effective policies for managing water demand. While much research has focused on some particular aspects based on several theories that contribute to the acceptability of new behaviors, other factors that significantly explain these actions have been overlooked. To better understand how individuals use and conserve water, this study set out to identify significant social, psychological, and behavioral aspects. To obtain the data for **<u>the first project</u>**, a total of 625 international students and employees from various universities in Fukuoka, Japan, participated in a survey. According to the structural equation modeling results, the suggested model accounts for 46% of the variability in water conservation activity. Attitude, responsibility, and culture were strongly correlated with awareness of water issues. There was a clear relationship between attitude, responsibility, and emotion, except for culture. Finally, significant and favorable relationships have been found between water conservation behavior with emotion, culture, habit, and involvement. This study combines these components into a single model to more accurately characterize individual water conservation behavior. According to the sequential regression model, all drivers, including demographic factors, increased the variation's contribution to water saving to 53%. The positive attitude, mood, and water-saving behavior of female participants were much higher than those of male participants. When compared to younger individuals, older participants had higher degrees of awareness, culture, habit, and water conservation behavior. Finally, participants thought that consciousness of water issues was the most crucial factor in behavior related to water conservation. In **<u>the second project</u>**, another questionnaire survey on 514 Japanese adults was also conducted to see how these variables influence their water consumption and conservation behavior. To examine the direct and indirect effects of socio-psychological and behavioral factors on consumption and conservation practices, structural equation modeling was carried out by controlling multiple demographic variables. The advocated model explained 57% of the variation in water conservation practices and 55% variance in water consumption. Individuals' awareness of water issues was found to be linked to attitudes, responsibility, water use habits, involvement, and emotion.

Furthermore, the attitude had a strong positive relationship with habit and emotion, and responsibility significantly influenced emotion and involvement. Finally, water conservation behavior was strongly and positively associated with emotion, habit, and participation, whereas water consumption was negatively linked to emotion, habit, and involvement statistically. The analysis also indicated that higher-income respondents conserve less water and use more water than lower-income respondents. Moreover, as people get older, their water conservation behavior improves while their usage decreases. Similarly, when the number of rooms and family size expands, water conservation actions decrease, and water use increases. Water conservation is crucial to guaranteeing future water availability in a world where natural resources like water are becoming increasingly limited. These findings may help policymakers improve household awareness, responsibility, and participation in water conservation measures.

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Chapter 1

Introduction

1.1 Background

Every individual has the freedom to live in a society where access to clean water is uncomplicatedly given. Water has always been essential to maintaining both human life and the ecosystem. Water is necessary to produce energy, food, belongings, and amenities in many sectors of society. One of the primary issues addressed by the Sustainable Development Goals is the reliable and sufficient availability of water [1]. In many places of the world, substantial improvements in water withdrawal, contamination, lifestyle, and environmental changes have resulted in severe water scarcity [2,3]. These changes cause ecological imbalances, which may worsen water shortage in particular locations [4,5]. It is now necessary to look into specific actions to conserve water resources to deal with the rising water demand [6,7]. Currently, over 2 billion people face the threat of losing access to freshwater supplies. By 2050, at least one in every four people will reside in a nation with severe water shortages. These issues can be resolved with increased planning, collaboration, investment, and technological innovation [1]. To enhance access to drinking water in various developing countries, particularly in Sub-Saharan Africa and the Asian area, more funding is therefore required for local management of freshwater systems [8].

Water scarcity is already affecting over half of the world's population [9], and future social and ecological changes are expected to exacerbate [4]. Urban regions are more vulnerable to water scarcity, which is one of the most pressing challenges today [10,11]. It is also regarded as a severe threat to the sustainable advancement of human societies [12]. Many global studies offer general management options to address water scarcity, such as increased spending on freshwater management systems, better coordination of activities, desalination, efficient irrigation facilities, financial incentives, and technological renovation [1].

Japan, an Asian country, has faced severe water shortages several times, including in 1964 in Tokyo, 1967 in Nagasaki, 1973 in Takamatsu, 1978 in Fukuoka (Fig.1.1), and so on. In 1994, a water crisis devastated practically all of the country. Approximately 16 million people were affected at least once by a suspension or reduction in water flow and suffered 140 billion yen in agricultural productivity [13]. During the drought of 1978, Fukuoka received barely 70% of typical rainfall and lacked sufficient reservoirs and dams. The city's water supply had to be reduced for 287 days. This was the first instance in Japan that a city with a population of over one million had experienced such a long drought. Due to the drought, Fukuoka City has been known for its severe water shortage. Fukuoka City began attempts to become a "water conservation-conscious city" after learning vital lessons from the catastrophic drought [14].

Fig. 1.1 Fukuoka drought 1978

Source: Fukuoka City Waterworks

Fukuoka city adopted an "Ordinance on the Promotion of Water Conservation" in 2003 as a first step toward becoming a water-conscious community. This is Japan's first water conservation ordinance to be put into effect. With the community's help, it is intended to create an environmentally friendly and drought-resistant city while facilitating a reliable water supply. Fukuoka is encouraging the construction of water recycling facilities that treat wastewater or rainwater and reuse the treated water for other uses, such as flushing toilets and agricultural irrigation. There are three different kinds of these facilities: 1) "individual circulation type," which uses water recovered from wastewater; 2) "wide-area circulation type," which uses recovered water delivered from a wastewater treatment plant; and 3) "non-circulation type," which uses cleaned rainfall. A water control center was set up in Fukuoka City in 1981 to regulate "water flow between water purification facilities" and "water pressure inside distribution pipes throughout the city." A significant contribution to the efficient use of water is made through continuous monitoring of flow meters and water-pressure gauges, as well as remote-controlled motor valves, which enable smooth flow adjustment and exact water pressure adjustment. Fukuoka City has methodically implemented leak detection procedures to reduce the loss of precious water resources and utilize them effectively. The city typically replaces distribution pipes every 40 years because outdated pipes might increase the likelihood of leaking. Fukuoka City declared June 1 to be "Water-Saving Day" in order to remember the lessons learned from the drought in 1978. The city runs a "water-saving program" every year from June to August.

Additionally, the city works to maintain high public awareness of water conservation to promote the "careful use of water as a finite resource." Public relations activities carried out year-round, such as distributing literature to all households in the city, issuing a guidebook for schoolchildren, and study tours to waterworks facilities. As a result, the people of Fukuoka City are very conscious of the need to save water. Even though there have been fewer water shortages recently, it is still important to understand how Japanese people consume and conserve water to prepare for potential future shortages.

1.2 Importance of conserving water

Having enough water is one of the biggest problems facing the planet. Individuals play a critical role in this circumstance; they should be actively involved in developing and adopting sustainable practices. Water authorities understand the need to minimize water demand while ensuring future water supply [2]. Demand management strategies are generally the most environmentally, socially, and economically sustainable solutions that can help consumers adapt to more sustainable water consumption habits [15–18]. Nowadays, the main objective of water demand management is to encourage households to conserve water by altering their water-use habits [16]. Typically, households conserve water by cutting back on water use [19]. Residential water conservation, which includes behavioral conservation [20], which relates to "daily actions to save water" [21], has gained considerable attention. Daily efforts involve replacing leakage taps, reusing grey water, taking shorter baths, shutting off taps when brushing teeth, and using the full-load dishwasher.

Conservation behavior relies heavily on a large-scale social shift toward an environmentally responsible lifestyle, which can be facilitated by encouraging individuals to engage in sustainable behavior [22,23].

Additionally, efficiency behavior, a different type of water-saving behavior, necessitates greater technological investment and human involvement (i.e., installing water- saving appliances at home) [24]. It utilizes various water-saving equipment, including dual-flush toilets, water-saving washing machines, and low-flow showerheads [3,25]. The widespread use of water-saving technologies could result in significant water savings [16,26,27]. Studies show that switching to water-efficient appliances for all household appliances can reduce water use by 35 to 50% [6,26].

1.3 Situational and demographical characteristics

Water consumption and conservation behavior are significantly influenced by some situational factors, such as building types and residents' tenure status [28]. Previous research has indicated that homeowners use less water than renters, while people of detached homes report more intention to conserve water [29,30]. The availability of water meters encourages people to save water. According to economists, when prices increase, less water will be consumed or desired [30]. Many localities successfully employed this strategy during the drought in the southeastern United States, and it may be the best long- and short-term answer to overuse. The restriction is another situational issue. In drought, water providers and/or governments frequently impose water restrictions, which demonstrably lower usage [31]. In many situations, planners would find it more beneficial and productive to impose water usage restrictions in addition to introducing alternate strategies. According to research, water use is also explained by socioeconomic factors, which can inhibit or promote behavior [28]. Water consumption is higher in households with more residents [6,32]. More educated households have a greater desire to conserve water [33], whereas other studies show that more education is also associated with greater water use [32,34]. Higher-income has been linked to stronger intentions to set up water-efficient appliances [35] and, in some cases, higher water use [21]. Older residents generally use less water than younger residents [30,36]. Furthermore, contextual factors such as the type of house, current living status, and the number of rooms have been shown to influence water consumption and conservation behavior [6,21,37].

The general notion of conservation behavior also includes the importance of personal capability [38]. Sociodemographic factors like age, education, and income can operate as proxies for personal ability. This capacity, such as expertise and abilities, can boost conservation actions. For instance, a person with better income and education may be more aware of the need to conserve water and more likely to install water-saving appliances that can significantly lower family water usage [39].

1.4 Psychosocial and behavioral characteristics

Studies in environmental science are increasingly examining what influences water use and conservation. In the water conservation and consumption context, recognizing the psychosocial and behavioral motives can help policymakers devise more efficient demand management measures and encourage more conservation behavior [3,7,21,28,40,41]. Several studies have discovered that psychological factors which include intentions, attitudes, values, beliefs, subjective and personal norms, self-identity, behavioral control and emotion [32,42–44] are the substantial factors of water consumption and conservation behavior. Besides this, social issues such as individual involvement, environmental awareness, sense of responsibility [45–48] and behavioral determinants like habits [28,41,49] are the most significant determinants of water use behavior. In addition, water price [30,50,51] and the installation of water-saving appliances [31,52] are also important parts of an individual's water conservation and consumption pattern.

Psychological Factors: Intention shows a drive or desire to perform an activity, and is the most direct predictor of pro-environmental behavior. Attitudes refer to a positive or negative assessment of a given action or thing, subjective norms provide views of social support from significant individuals for a particular behavior, and perceived behavioral regulation describes how self-controlled the activity is perceived. Personal moral convictions about the environment are also articulated as sense of obligation to use natural resources carefully, and these feelings may positively influence pro-environmental behavior. Additionally, emotion denotes physiological activation, is connected to expressive behaviors, is related to conscious experience, and is a fundamental component of many human endeavors. Emotions are subjective feelings that cause people to feel certain things, like anger or joy. This emotional attachment to the natural world strongly correlates with self-reported conservation behavior and is an influential driving factor behind environmental protection initiatives.

Social and Behavioral Factors: Environmental consciousness is the main factor in recognizing our environment's vulnerability and the significance of its preservation. A sense of duty is similar to knowing and carrying out one's responsibilities. Socially responsible persons are usually more willing to save water than others. Personal involvement is determined by the degree of personal significance associated with a particular object, circumstance, or action, which in turn depends on one's motivation to act and process information. In addition, habits related to water use and conservation may include cleaning clothing and dishes with minimal water, taking shorter showers and baths, and watering the yard with a bucket of water instead of hose. The amount of intellect needed to make daily decisions can be reduced due to these behaviors, which are the result of automated cognitive processes created through repetition.

Evidence supports that each of these factors is a significant predictor of water conservation behavior. The results are somewhat inconsistent, though. According to research, participants in the United Kingdom have a good attitude toward water conservation, with 83% of respondents saying that households need to do so [39,53,54]. However, this is a lesser percentage than comparable Australian surveys, which discovered that 94–98% of participants thought it was vital to save water [55–57]. This discrepancy might result from greater knowledge of Australia's widespread water scarcity problems [53]. Research on public perceptions of water stress issues reveals conflicting views on the likelihood of water scarcity in the UK. According to studies, there is a direct link between contact with water scarcity awareness and actions taken to conserve water. The majority of those who said there was a low risk of water scarcity (69 percent) also claim to not be water conscious [54].

According to several studies, attitudes and subjective norms were ineffective at explaining variations in household water use; however, perceived behavioral control was a significant predictor of water conservation behavior [6,58]. This might be justified by the study's integration of contextual variables, and it was demonstrated that these variables accounted for a considerable part of home water use. This is another proof of the need for thorough, systematic research incorporating various determinants rather than just one type. For instance, contextual variables can significantly influence how well these psychosocial determinants predict outcomes, demanding the inclusion of both psychosocial and contextual variables in a single study.

1.5 Significance of the present study

To build any water-saving strategies, it is crucial to start by considering consumption and conservation behavior with related factors [59]. The current study investigates the fundamental factors of household water conservation and water usage behavior by combining demographic, situational, psychological, social, and behavioral aspects. As a consequence, we explore the relationship among water conservation, consumption, and related psychological (emotion, culture, and attitude), social (awareness, responsibility, and involvement), and behavioral (water use habit) aspects of the residents who live in the Fukuoka city, Japan. Fig. 1.2 displays the variables that make up the current investigation.

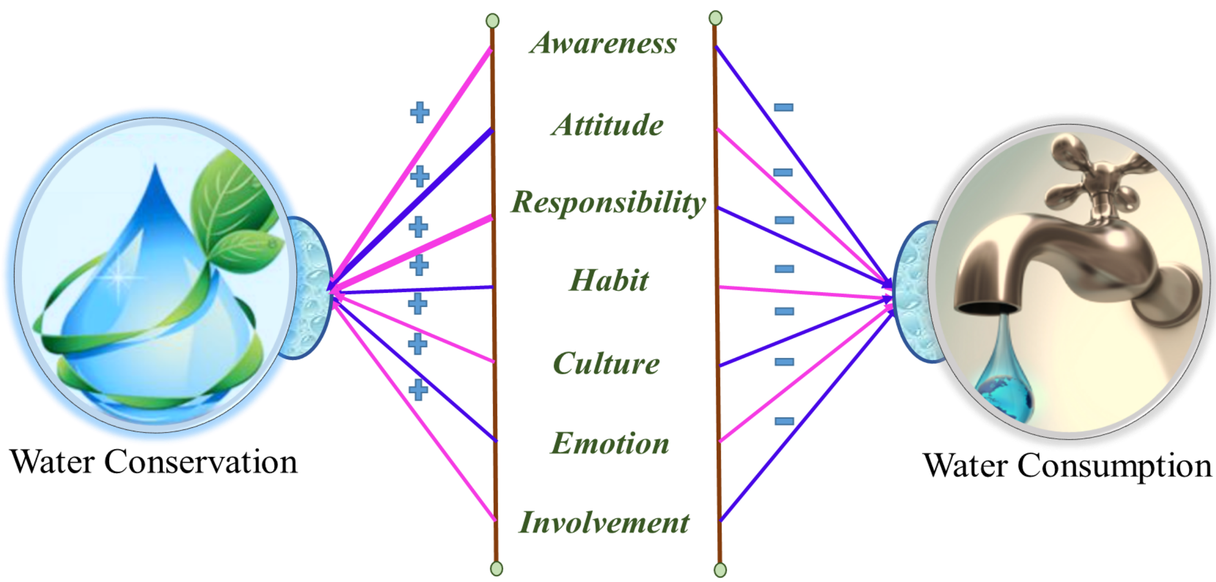

Fig. 1.2 Essential psychological, social and behavioral factors of water consumption and conservation behavior

This study contributes to the current body of knowledge by extending the study of individual consumption and conservation behavior in a variety of ways. The general goal of this study is to bridge the research gaps by combining psychological, social, behavioral as well as demographic and situational aspects as control variables into a single model and testing empirical hypotheses related to water-saving behavior and consumption patterns. Furthermore, we propose an innovative model in this paper that incorporates multiple predictors such as attitude, emotion, culture, awareness, responsibility, involvement, and water use habit, along with demographic factors as a control variable, to explore a wide range of water conservation activities and consumption patterns in the residence. Some studies relate water conservation behavior to each of these elements separately, whereas others merely link the amount of consumption, which is insufficient [6,42,60–66]. To our knowledge, no empirical study has ever been conducted in Japan on the relationship between psychosocial and behavioral components with conservation and consumption behavior. We use a structural model and an ordered logistic regression to look at the impact of these several elements on water conservation behavior and consumption. By gradually including the components in the model, this study also used sequential regression analysis to assure robustness.

This study is important from both a theoretical and a practical perspective. It is impossible to exaggerate the value of conserving water supplies to the economy and ecology. All commercial operations would collapse in the absence of water. All life, including humans, would cease to survive in the absence of an ongoing source of pure, fresh water. Theoretically, this study has the potential to increase our understanding of some topics. Comparing studies conducted in several nations reveals variations in the cultural predictors of water conservation behavior. This might improve the knowledge of water conservation practices across cultural boundaries.

1.6 Research Objectives

The present study comprises two main research projects. The first project emphasizes the psychological (attitude, emotion, and culture), social (awareness, responsibility, and involvement), and behavioral (habits) determinants regarding the water conservation behavior of international students and employees who are residing in Fukuoka, Japan. The objectives were as follows:

- Develop a questionnaire (English version) to measure the psychological, social, and behavioral determinants or factors of water conservation behavior.
- Ensure the reliability and validity of the questionnaire by following different statistical techniques.
- Measure the effect of psychological, social, and behavioral factors on individual water conservation activities using a structural model.
- Determine these factors' distinct and combined impact on conservation behavior using a sequential regression model.
- Identify the most dominating factor behind the individual conservation behavior.

The second project emphasizes the demographical (age, gender, profession, educational level, and income level), situational (current living status, types of house, number of rooms, and number of family members), psychological, social, and behavioral determinants regarding water consumption and conservation behavior of Japanese peoples in Fukuoka, Japan. The objectives were as follows:

- Translate the questionnaire into Japanese to measure the several factors of water consumption and conservation behavior.
- Confirm the reliability and validity of the translated version of the questionnaire.
- Examine the direct and indirect effect of psychological, social and behavioral factors on water consumption and conservation activities using structural model.
- Recognize the effect of control variables (demographic and situational factors) on water consumption and conservation level.
- Confirm the robustness of the results by carrying out an ordered logistic regression analysis.

1.7 Thesis Outline

The framework of the Ph.D. thesis consists of five main chapters as follows:

Chapter 1 provides background information about the water shortage of different places, including Japan, and possible explanations. Moreover, this chapter confers the importance of conserving water and discusses several psychological, social, and behavioral variables in properly comprehending how individuals use water and make water-related decisions. This section includes the significance of the current study and presents the research objectives of two projects.

Chapter 2 summarizes the study's theoretical background based on a literature review. This section contains diverse theories related to water-using behavior, such as the Theory of Reasoned Action, the Theory of Planned Behavior, the Social Cognitive Theory, the Value-Belief-Norm Theory, and so on. This chapter presents these theories clearly and precisely with a theoretical model to better understand them.

Chapter 3 introduces the proposed model and study hypotheses (first project), followed by a discussion of the key survey methodologies, including sample, questionnaire construction (content validity and reliability), data collection, measurements, and data processing procedures. In detail, this chapter comprises the method of analysis, why this method is used, types of methods, steps of the analysis, and relevant model fit indices to determine the proposed model fit or not. Finally, chapter 3 reveals the results of the first projects regarding the impact of several factors on the water conservation behavior of international residents. The results were obtained through the measurement model, structural model (path analysis), Pearson Product Moment correlation, multiple regression, and sequential regression model.

Chapter 4 explains about the proposed model, hypotheses, sample selection, data collection procedure, and results of the second project. This chapter demonstrates different types of reliability and validity of the questionnaire based on the Japanese version, path analysis, correlation test, ordered logistic regression model, and direct and indirect effects of psychological, social, and behavioral factors on water consumption and conservation activities. Chapter 4 also depicts the influence of demographic and situational determinants on consumption and conservation patterns.

Finally, **Chapter 5** highlights the findings, discussion, potential implications, and limitations. In addition, it presents some recommendations for prospective investigators suggesting that more research is needed to have a better knowledge of the drivers of water use behavior to build successful water demand management approaches. Lastly, chapter 5 finishes with possible research ideas for future work.

Chapter 2

Theoretical Framework

2.1 Theoretical background

Numerous attempts to explain the factors connected to people's participation in a particular pro-environmental activity have been made in the environmental literature. Early fundamental theories of pro-environmental behavior predicted that increased environmental awareness and a favorable attitude toward the environment would encourage pro-environmental conduct. The environmental psychology field has played a significant role in describing water consumption and conservation behavior as well as exploring influential determinants by providing a broad range of socio-psychological theories.

2.2 The Theory of Reasoned Action (TRA)

TRA is the most widely used and scientifically justifiable theoretical framework [67]. According to the theory of reasoned action (Fig.2.1), behavioral intention is influenced by attitudes and subjective norms [10,40,68–70]. The most accurate indicator of whether someone will engage in an activity is thought to be their intention to do so. Attitudes and subjective norms, in turn, predict intentions. A person is more likely to engage in a behavior or action if they have a positive opinion of it and believe it to be beneficial to their friends, family, or society. Attitude results from behavioral belief, or salient information, the perceived likelihood that engaging in a given behavior would produce a specific consequence, weighted by how highly the outcome is valued. A person's subjective norm is a result of their normative belief, which is the perceived pressure from particular referents to engage in the target action, as well as their incentive to do so out of concern for them. Intentions hold a prominent position because it is now apparent that attitude and behavior are not directly related.

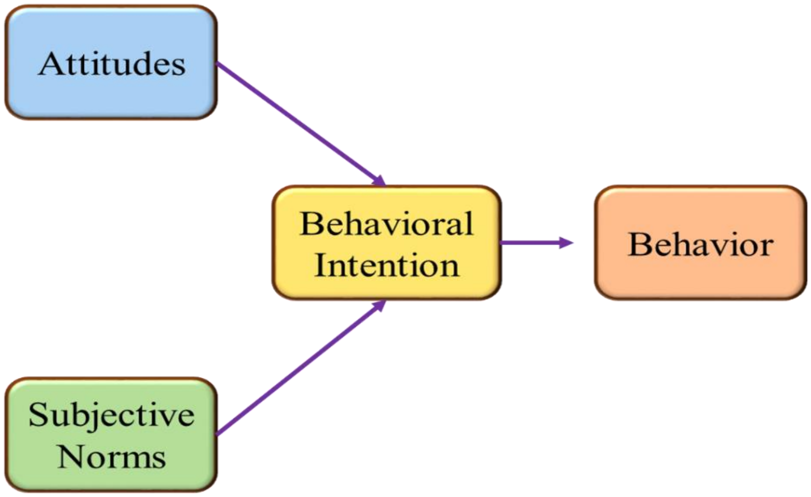

Fig. 2.1 The Theory of Reasoned Action (TRA)

2.3 The Theory of Planned Behavior (TPB)

TPB is a well-known and extensively utilized socio-psychological framework for explaining behaviors, especially pro-environmental [6,43,71–74]. In this model (Fig. 2.2), the best predictor of behavior is intention [75–77], and intention is determined through attitude toward the behavior [78,79], perceived behavioral control [80,81], and subjective norm [6,82]. The motivating elements that impact an action are captured by intentions, which are signs of how much effort someone is prepared to put forth to carry out the conduct. Generally speaking, the likelihood of behavior should increase with the strength of the intention to engage in it. Attitudes comprise two distinct but intricately linked parts, including emotional and cognitive components. When discussing a topic, the emotional component refers to how the person feels, whereas the cognitive component places more emphasis on their beliefs [83]. A person's impression of societal pressure to perform or refrain from performing an activity is referred to as a subjective norm. People frequently behave based on their assumptions about how others would see them, and the people they have close relationships with significantly impact whether they are willing to accept a possible behavior [84]. Perceived behavioral control (PBC), the third determinant, is the degree to which a person perceives that action is under their self-control. It refers to a person's perception of the ease or difficulty of carrying out an action [85]. TPB is a compact model that enables researchers to extend the original TPB with additional predictors pertaining to a specific behavior. According to the TPB, behavioral, normative, and control beliefs—commonly referred to as indirect predictors—are said to have an impact on the three determinants of intention. Normative beliefs are "a person's subjective possibility that a particular normative referent intends the person to execute a given behavior." In contrast, control beliefs are connected to various elements (such as time, money, accessible infrastructures, etc.) that either impede or facilitate a behavior. Behavioral beliefs are the perceived benefits and drawbacks of engaging in a particular behavior. The TPB has been used a lot to investigate the reasons motivating different pro-environmental actions since it was introduced about three decades ago: the use of substitute transportation [86], wastewater recycling [87], saving water [35,88], energy conservation [89] and others.

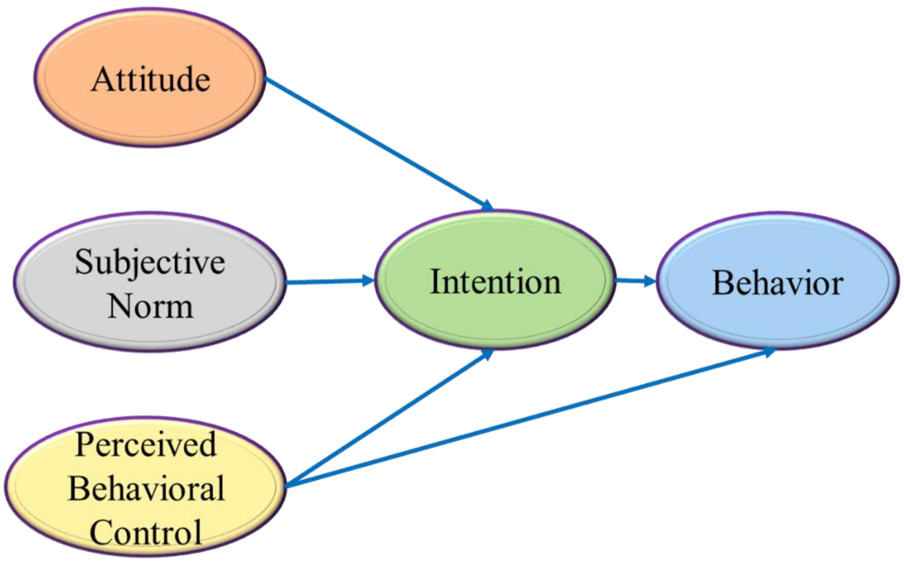

Fig. 2.2 The Theory of Planned Behavior (TPB)

2.4 Norm Activation Model (NAM)

This theory is primarily grounded in altruistic behavior and states that a person sacrifices their own self-interest for the collective good of others [90]. The Norm Activation Model identifies personal norms, an ascription of responsibility, and awareness of consequences as the three main factors that predict pro-environmental behavior (Fig. 2.3). Personal norms can be described as a form of self-discipline that is connected to pro-environmental activities. This is a primary determinant of pro-social behaviors. The term ascription of responsibility refers to an individual's subjective judgment of his or her level of accountability for the results of their actions. A person's assessment of the severity of his or her own behavior on the welfare of others is referred to as awareness of consequences. Personal norms are activated when people are aware of the consequences of performing or not performing a specific behavior and when they accept responsibility for those consequences [75,91,92]. This model has been used extensively in earlier research to examine pro-environmental behaviors in a variety of contexts, including public transport services, energy use, carbon emissions, and acceptance of responsible technology [93–95].

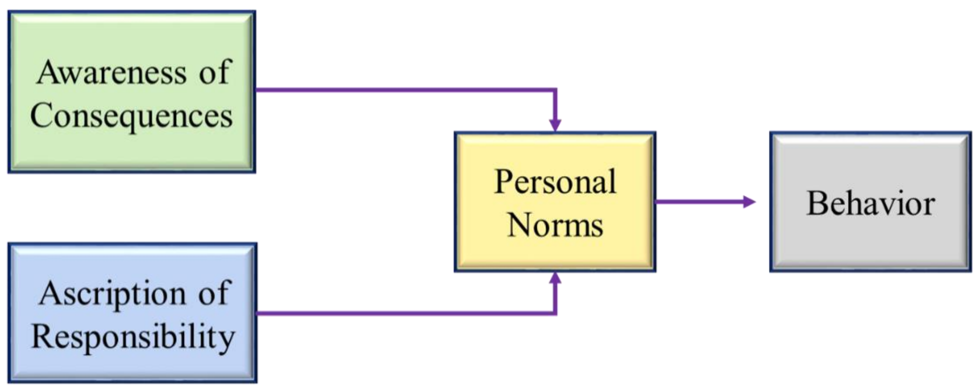

Fig. 2.3 The Norm Activation Model (NAM)

2.5 Value-Belief-Norm Theory (VBN)

The Value-Belief-Norm theory, which links the values theory, norm activation theory, and beliefs (Fig. 2.4), was proposed by Stern [96]. Numerous researchers discovered that pro-environmental behaviors might emerge when people feel obligated to engage in the behaviors and are aware of the detrimental impacts of their actions on the environment by using the value-belief-norm paradigm [62,92,97]. This theory is intended to fit environmentalism's context by accentuating pro-environmental behavior, and it includes another two important concepts, ecological worldview, and values, [96,98]. People with a more positive ecological worldview believe that people overuse natural resources, and that's why environmental conservation is a worldwide necessity [46,76,81]. Value states a guiding concept for any activity based on desirable trans-situational goals, which vary by relative importance. Altruistic, biospheric, egoistic, and openness to change values were all included in the value components. According to this theory, there are causal links between values, beliefs, norms, and behaviors. The VBN theory has been applied to a variety of populations and is frequently used to explain the connection between socio-psychological characteristics and pro-environmental behavior. For example, it has been applied to comprehend energy conservation practices [62,99], customers' sustainable behaviors [100], and university students' ecological behaviors, such as how they like to travel and how much food and energy they use [101]. The VBN theory was investigated in these studies to determine which predictor variables (values, beliefs, attitudes, and PN) account for pro-environmental behaviors.

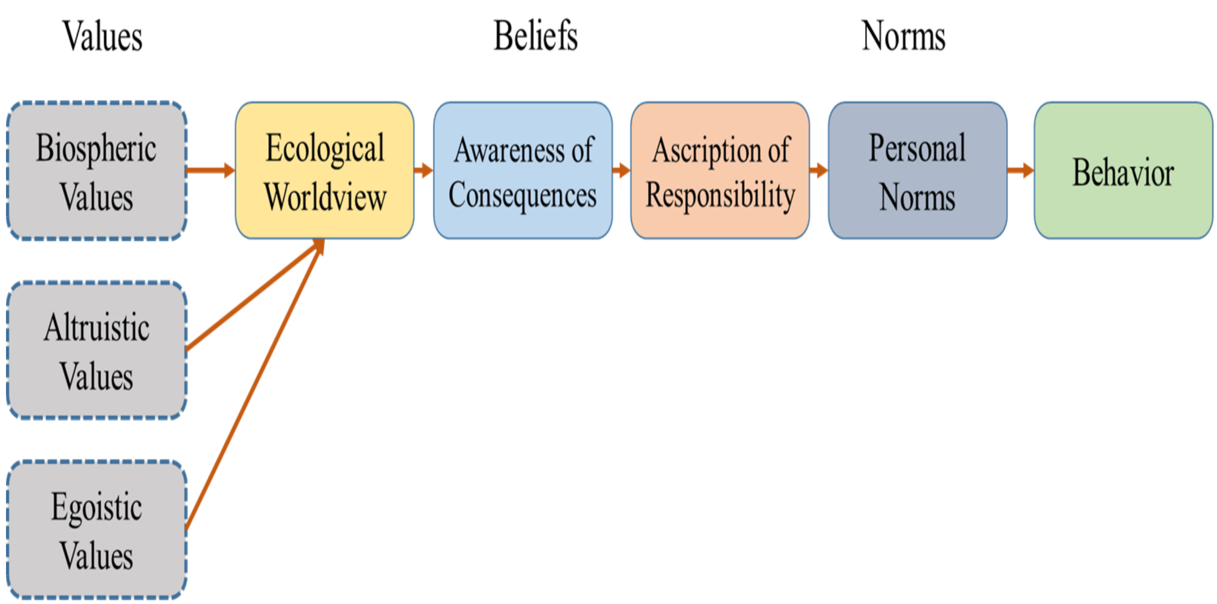

Fig. 2.4 The Value-Belief-Norm Theory (VBN)

2.6 Social Cognitive Theory (SCT)

This is a valuable theoretical framework for exploring psychosocial mechanisms and variables that affect people's feelings, ideas, and behaviors [102,103]. To comprehend the connections between individual, behavioral, and environmental factors, research has focused on SCT [104]. According to SCT, an individual's behavior is influenced by a variety of personal, environmental, and behavioral factors, which is the result of the interaction between an individual's beliefs, which include outcome expectations, self-efficacy beliefs, and a sense of volitional control, and the social and physical environment in which behavior occurs (Fig. 2.5). Outcome expectations and self-efficacy serve as a guide for an individual's behavioral intentions, and socio-structural elements also have an impact on that individual's behaviors [63,105,106]. The learning that takes place in a social context is highlighted by social cognitive theory. According to this perspective, individuals are active agents who have the power to both affect and be impacted by their environment. A wide spectrum of human behavior, including both good and bad social behaviors like violence, pro-environmental behavior, substance misuse, and mental health issues, has been explained by social cognitive theory [107–109]. Two essential elements of SCT are self-efficacy beliefs and outcome expectations. A judgment regarding the anticipated effects of engaging in a particular behavior, or a kind of motivation for people to engage in a specific behavior, is known as an outcome expectancy. This is significant because, in most cases, people behave in a particular way only when given the incentive to do so. Having such a reward can encourage people to make goals for their futures and inspire themselves cognitively [103,110]. Another important factor in SCT is self-efficacy, which can be described as a person's perception of how easy or difficult it is for them to do a particular activity and their level of self-assurance in that capacity. According to SCT, people who are more self-assured in their abilities are more prone to start challenging behaviors. As a result, assessments of one's ability to carry out the courses of action necessary to handle future events are a focus of self-efficacy. According to many academics, self-efficacy is the most crucial precondition for behavioral change and acts as a mediator between one's cognition and behavior [103].

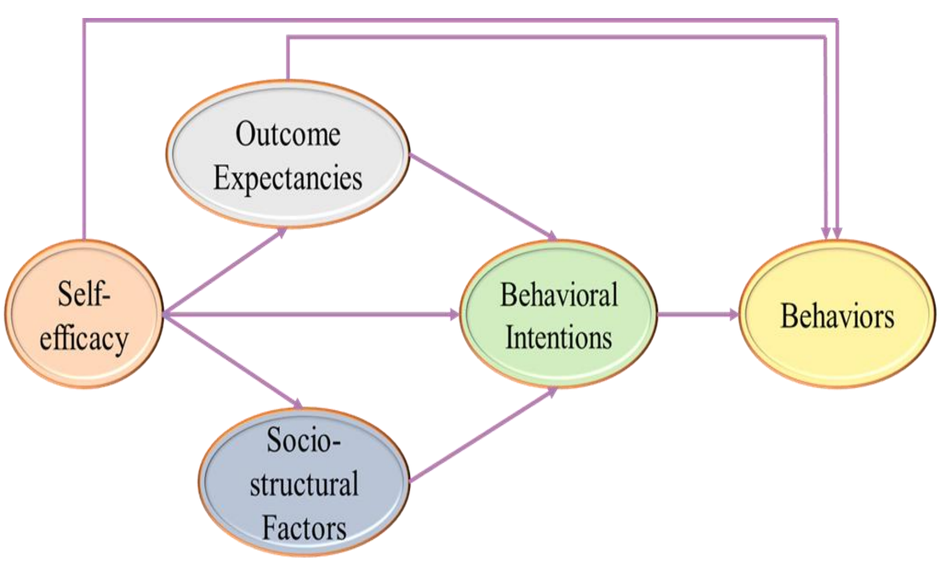

Fig. 2.5 The Social Cognitive Theory (SCT)

2.7 Health Belief Model

This classical model explains individual behavior's complexities and multiple perspectives [17,111]. It focuses on people's ideas about their decisions and is the most prevalent and widely used theoretical model in health-promotion behavior and preventive health behaviors (Fig. 2.6). People are more likely to take preventive action (water conservation behavior) when they feel and believe they are at risk (water scarcity) [10,112,113]. Furthermore, this model explains why certain people choose not to engage in preventive behaviors [111,114]. This paradigm was created in the early stages of health research to explain and comprehend why people don't engage in preventive and detective health initiatives. However, many environmental behaviors have an impact on human well-being and health. The HBM has been successfully used to forecast a variety of pro-environmental behaviors, such as the use of renewable energy, the testing of private well water, the management of household wastewater treatment systems, the response to extreme weather events, the adoption of rainwater harvesting, drought adaptation behaviors, and farmers' conservation behavior [17,39,115].

Perceived threat and perceived expectancy are two behavioral assumptions HBM predicts to occur most frequently. Perceived vulnerability and perceived severity are two of the subcomponents that make up the perceived threat. People's opinion of the risk or likelihood of developing health problems is known as perceived susceptibility or perceived vulnerability, while their assessment of the seriousness of the medical and social implications of that problem is known as perceived severity. Perceived expectation also includes perceived benefits [116], which are the advantages that come from engaging in healthy behavior and are related to how well-defined actions work to reduce the risk of developing health problems and potential barriers to engaging in healthy behavior [117]. Later, to improve behavior prediction, researchers incorporated the three motivational categories of cue to action, self-efficacy, and general beliefs [118]. They anticipated that these new structures could improve the model's capacity for explanation [119]. Cues to action include a variety of catalysts, such as physical discomfort or disease, media exposure, and social pressure, that stimulate a person's interest in making a change by raising their awareness about the detrimental effects of a health issue [120]. Self-efficacy is described as the belief that one can successfully complete a task, whereas general beliefs are one's values, specific views, and worries about overall health issues [121].

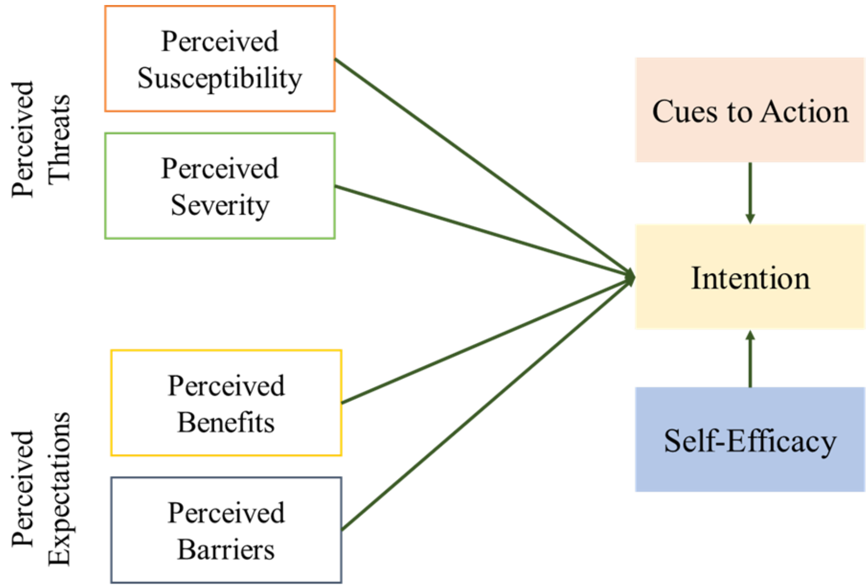

Fig. 2.6 The Health Belief Model (HBM)

2.8 The Comprehensive Action Determination Model

This model is an effort to overcome the drawbacks of the single models and provide a broad model framework (Fig. 2.7) that would be applicable in a wider range of circumstances [122]. The theory of planned behavior and the value-belief-norm theory, two of the most frequently cited theoretical frameworks in conservation works, are combined in this model [81] to create an integrative structure for categorizing the factors that influence conservation behavior. This model's key premise is that individual behavior is directly influenced by impacts from three different sources, including intentional, situational, and habitual factors. According to CADM, attitudes, societal norms, perceived behavioral control, and personal norms all have an impact on behavior, and the psychosocial determinants of intention act as an integrative variable to link these influences. The CADM differs from earlier psychological models in that habits are a significant component of behavior. Intention-behavior relationships are also thought to be moderated by habit strength, implying that these relationships are weaker when habits are strong. In the past, when a behavior was carried out for the first few times, PBC and intents were the key determinants. It became internalized via repetition, and it supplanted the two variables as the controlling factor. But if intentions, personal norms, and behavioral control did not change, they would continue to be associated to habit strength because they influenced behavior at an earlier period. In a number of investigations across several behavioral domains, the hypothesis has gained strong empirical support [123,124].

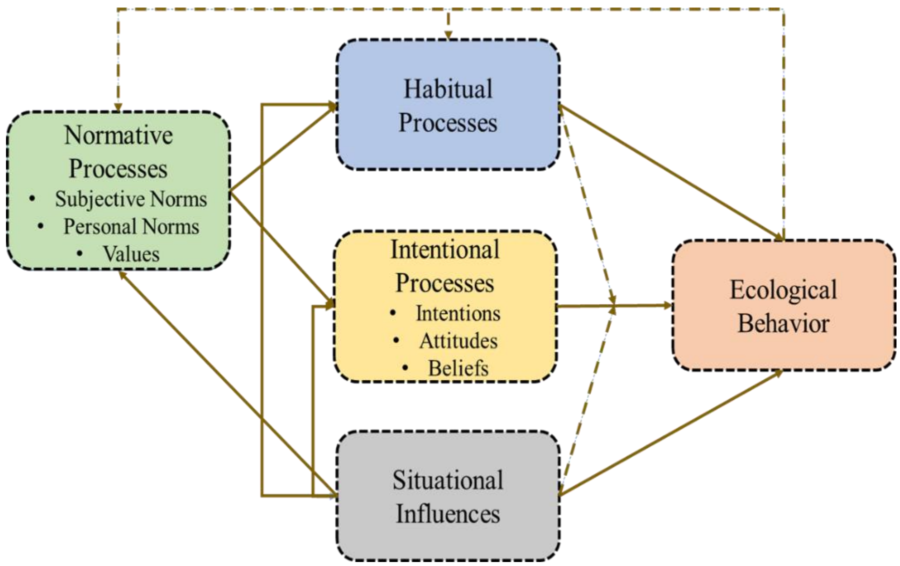

Fig. 2.7 The Comprehensive Action Determination Model (CADM)

Aside from the factors mentioned in the preceding theories, there is recognition in the environmental science and applied psychology literature that there are some additional determinants that can influence our water-related behavior. Environmental psychologists have begun to consider emotion as a fundamental component of motivation. Positive and negative emotions are predictive factors of resource-saving efforts [65]. A strong motivator of eco-friendly behavior is this emotional attachment to nature [80,125,126]. However, researchers hardly ever look into these emotions unless these emotions are connected to cognitive categories [127]. Previous research has consistently demonstrated the value of theoretical models based on emotions and the significance of emotions in predicting pro-environmental behaviors [128–131]. Particularly, the adoption of pro-environmental practices is made easier by the negative emotional responses caused by environmental degradation. One way to comprehend the connections between emotions and environmental engagement is via the lens of moral dilemmas. Another method to comprehend the links is through one's affinity for nature, which is undoubtedly the strongest feeling connected to an environmental identity [65]. The current study aims to assess people's emotions regarding water consumption in light of the necessity of water for human survival considering the emotions as predictors of environmental participation, and these specific measures connected to water issues are essential in predicting water conservation.

Numerous researchers found that when people feel responsible for engaging in the behaviors and are aware of environmental challenges, pro-environmental behaviors may emerge [62,92,97]. Besides this, households with higher levels of participation in and knowledge of water-related challenges used less water [32]. Several empirical studies have confirmed awareness as an important factor in environmental behavior [64,132]. Households with higher environmental awareness practiced more water conservation and consumed less water than those with lower environmental awareness [3]. However, awareness does not always result in environmentally conscious behavior. [133] contended that our attitude, as a mediating variable, can help explain the effects of awareness on conservation behavior.

Involvement can also result in a greater concern for a society's welfare, a decrease in excessive consumption, and even a concerted opposition to unsustainable practices [134]. The degree of perceived significance or interest aroused by a stimulus in relation to a particular thing, circumstance, or action is known as involvement [135]. The personal relevance degree varies according to each person's intrinsic needs, values, and interests. Investigation on involvement has been applied in such extents as commitment [136], purchase importance and situational involvement [137], comprehension [135], and customer profiling [134]. Personal involvement is a reasoned motivator that encourages people to seek more knowledge and spend more time reflecting on their own behavior. However, the idea of personal engagement has not been articulated explicitly or included in the literature on environmental behavior. A consumer's level of involvement, as an intervening factor in water consumption and conservation behavior, can influence his or her day-to-day water usage activities [45,138]. For example, suppose a consumer is concerned about the security of his or her water supply and participates relevant campaigns, initiatives, or programs. In that case, he or she may be motivated to conserve water. Individuals develop pro-conservation behavior when involvement levels are high, which directly contributes to lower water usage levels [32,58,73].

Water use in the home is a shared behavior involving numerous household members' actions. Without other members of the home holding the same culture, a single person's commitment to water conservation is unlikely to affect lowered household water use [73]. As a result, household culture may play a significant role in residential water demand. According to this viewpoint, studies showed that people's intentions to conserve water are stronger when they see other people doing so [29,33,35,139].

Applied psychology and sociology domains demand the inclusion of habits or practices in comprehensive approaches that evaluate long-term behavior [92]. The degree of a behavior's habituation can theoretically be analyzed on two different levels. The first one is related to the characteristics of the behavior itself, such as its regularity and situational stability, and other related to a person's characteristics, such as the degree to which one individual is habituated in a position compared to other individuals in the same situation. This paper uses the second level of analysis. Researchers define a habit as a frequent and instinctive action based on a lack of preparation and limited mindful effort [140]. When existing circumstances change and seek a different action, a change in habitual behavior is reasonable [124]. Many studies argue that habits should be recognized as a critical, descriptive construct of a sustainable life [141,142]. Thus, habitual behaviors are controlled more by automatic processes than by deliberate thought. Evidence supports the connection between habits, intentions, and behavior related to water conservation. [53,81]. Researchers emphasize the requirement for the habit to be more than just a formal indicator of behavioral stability when used as an independent variable in an action model [143]. Strong habits reduce the link between personal norms and behavior and increase the amount of behavior that can be described by a given set of factors [144].

The current study integrates attitude, emotion, and culture as psychological factors, awareness, responsibility, and involvement as social factors, and water use habits as behavioral factors based on the discussion above.

Chapter 3

Water Conservation Behavior of International Students and Employees living in Japan

3.1 Research hypotheses

According to prior studies, environmental awareness is a foundation for taking action [64,145]. As a result, awareness is the first element of the conceptual framework. Fig. 3.1 presents the conceptual framework of the first portion of the current investigation. Based on the discussion stated above (literature review), the following assumptions are being examined. We expect that awareness would be a straight predictor for attitude (H_1), responsibility (H_2), and culture (H_3). Then, attitude (H_5), responsibility (H_4), and culture (H_6) would be the significant factors of emotion regarding water saving. Culture (H_7) and emotion (H_8) would be the direct indicators of habit and involvement. Lastly, emotion (H_9), involvement (H_{10}), habit (H_{11}), and culture (H_{12}) would be favorably and strongly associated with water conservation behavior.

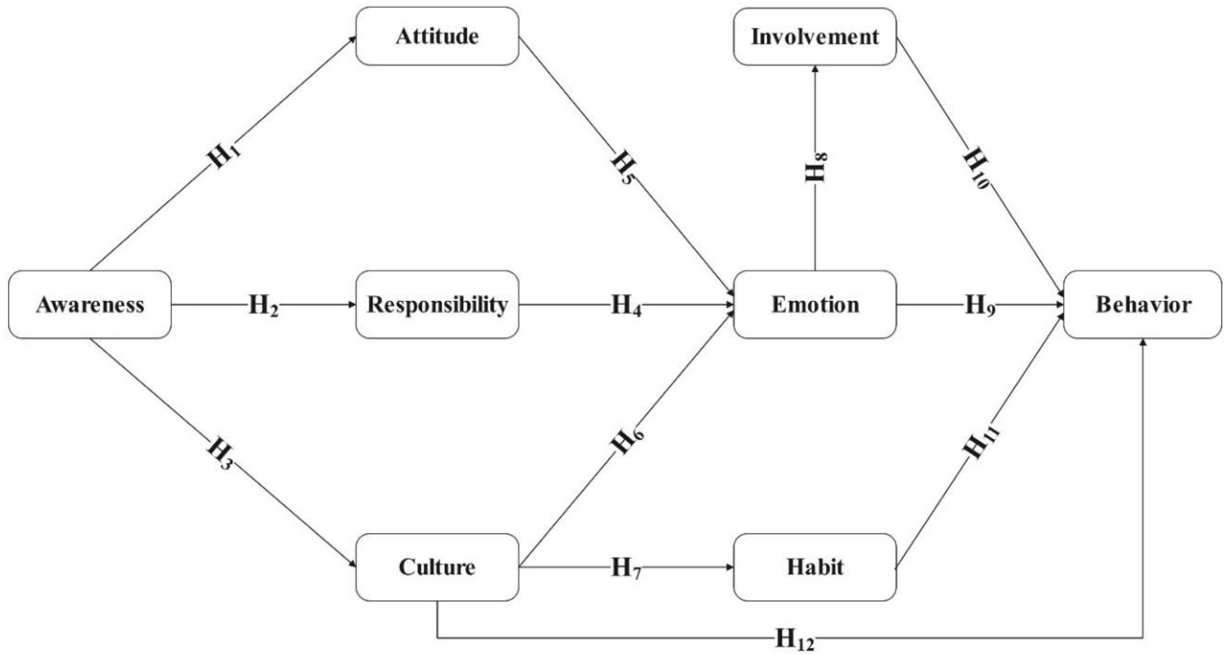

Fig. 3.1 The conceptual outline of the research on water conservation behavior of international students and employees living in Japan

3.2 Empirical Methods

3.2.1 Sample

The current study used a questionnaire survey method to conduct the analysis. The statistical population for this study was made up of foreign university students and staff members living in Fukuoka, Japan, who were at least 18 years old. Purposefully recruited respondents for the poll (n = 625) came from various universities. A web-based questionnaire was developed in response to the COVID-19 outbreak, and the possibility that respondents' desire to do an in-person survey may decline. Respondents who desired to participate in the online survey were also issued a consent form. Additionally, some written questionnaires were also distributed on campus to interested parties. The paper-based questionnaire's objectives were to increase response rates, enable a wide spectrum of people to take part in the survey, and prevent sampling bias. Lastly, the data were gathered in 2021 between February and June. Due to the cross-sectional methodology used in the current study, opinions may vary based on contexts, demographic features, and periods.

3.2.2 Measures

All of the research variables were analyzed using multiple-item scales. Based on a thorough analysis of earlier published research, we created eight multi-item measures to address the current study topic. The questionnaire contained 62 items in all at first (60 multi-item scales, one multiple-type question, and one descriptive statement). The measurement items of an individual's attitude (7 items), culture (6 items), and emotion (8 items) were adopted from the studies of [20,24,48,68,72,125]. The studies of [32,62,75,98] were used to develop the measures of people's awareness of water issues (7 items), sense of responsibility (8 items), and involvement (8 items). The measurement items of individual's water use habits (10 items) were adopted form [21,32,72,92], while items of conservation behavior (6 items) were considered from the studies of [6,24,28].

The content validity of measures was assessed in terms of item appropriateness and usability by a group of professionals with extensive water science and environmental psychology backgrounds. The questionnaire's face validity was then evaluated by giving paper copies to 25–30 employees and students who were selected through convenience sampling (not included in the next analysis). The final questionnaire had 51 acceptable items in all (49 multi-item scales, one multiple-choice question, and one descriptive statement). It was measured using a five-point Likert answer scale, with 1 being the strongest disagreement/never and 5 being the strongest agreement/always. For instance: The response "I check toilets, faucets, and pipes for leaks and fix them immediately" was used to assess conservation behavior. The statement "I am highly positive about water-saving" was used to determine attitude. In Appendices, constructions and measurement items are presented.

3.2.3 Analysis method

Structural Equation Model: The structural equation modeling method was used to assess the current study's hypotheses. AMOS 24.0 and SPSS 26.0 were utilized to evaluate the data. A statistical method called structural equation modeling (SEM) combines latent variables (factors or constructs) with a structural model to examine the relationships between theoretical concepts [146]. In behavioral and social research, SEM is a well-known and dependable multivariate statistical method for examining direct and indirect interactions [147,148]. The survey's items are the observed variables (indicators), whereas indicators can assess the latent variables (constructs)

[149]. Common quantitative techniques, including correlation, multiple regression, and analysis of variance (ANOVA), are comparable to SEM. SEM shares many similarities with these methods. First, general linear models provide the basis for all four statistical methods. Second, only some presumptions are true for all to be true. Thirdly, no one of these methods suggests causation. Even while causal linkages are hypothesized, causation can only be established by the validity of the underlying theory and research design, not by the outcomes of any of these procedures.

The ability of SEM to estimate and assess the correlations between constructs is one way in which it differs from other methodologies and one of its advantages. SEM permits the use of many measures to describe constructs and handles the issue of measure-specific error, in contrast to other generic linear models where structures may be represented with a single measure, and measurement error is not handled. This distinction is significant because it enables scholars to determine the construct validity of components. To assess whether the SEM model effectively captures the relationships between the constructs and observed variables, researchers must use numerous test statistics and a variety of fit indicators (i.e., whether the model fits the data). The measurement and structural models are the two crucial elements of structural equation modeling [149,150].

Measurement Model: The researcher can assess how well the observed (measured or indicators) variables work together to identify underlying hypothesized components using the SEM measurement model. This measuring approach uses confirmatory factor analysis (CFA) to examine and investigate the relationships between constructs and indicators [151]. Testing models that include constructs with single indicators is highly discouraged [152]. Each indicator should ideally be a distinct measurement of the hypothesized latent variable, when combined, representing the underlying construct.

Certain Fitness Indexes serve as indicators of a measuring model's fitness [153].

1. Unidimensionality: When all measuring items have suitable factor loadings for each latent construct, unidimensionality is attained. Any component with a low factor loading ought to be eliminated in order to guarantee this of a measurement model.

2. Validity: The ability of an instrument to measure what it is designed to assess for a latent construct is known as validity. For each measurement model, three different types of validity are necessary.

Convergent Validity. When every component of a measurement model is statistically significant, this validity is attained. The Average Variance Extracted (AVE) for each construct could be calculated to confirm the convergent validity further. The AVE value must be at least 0.5 to acquire this validity. Thus, keeping the items with low factor loading in a model can result in the construct violating convergent validity.

Construct Validity. When the Fitness Indexes for a construct reach a sufficient level, this validity is established. The fitness indices show how well the items are suited to measure each latent construct. The Fitness Indexes are presented in SEM steps along with the corresponding category and level of approval.

Discriminant Validity. This validity shows that there are no redundant items in the construct's measurement model. The correlation between exogenous/independent constructs should not be more than 0.85, which is one criterion for discriminant validity. The two exogenous constructs are redundant or have major multicollinearity issues if the correlation value is greater than 0.85.

3. Reliability: The degree to which a research tool consistently produces the same results repeatedly when employed in the same circumstance. The following criteria could be used to evaluate a measurement model's reliability.

Composite Reliability: A latent construct's reliability and internal consistency are indicated by its composite reliability. In order to attain composite reliability for a construct, CR must be greater than 0.6. (The formula is used to determine CR.)

Average Variance Extracted: The average proportion of variation for a latent construct that can be explained by the measuring items is shown by this statistic. Every construct requires an AVE > 0.5.

Composite reliability (CR) and average variance extracted (AVE) are calculated using the given formula:

$$AVE = \frac{\sum K^2}{n}$$

$$CR = \frac{(\sum K)^2}{[(\sum K)^2 + (\sum 1 - K^2)]}$$

Where K indicates the factor loading of every item and n represents the number of items in a model.

Structural Model: The proposed relationships between the latent variables are described by equations in the structural part of the model. Path analysis is employed in the structural model to link independent and dependent variables to study the relationship between constructs and test certain research hypotheses, [72]. Relationships between latent variables can be characterized as covariance, direct effects, or indirect (mediated) effects. Similar to correlations, covariance is described as non-directional associations between unrelated latent variables. Similar to the links revealed in ANOVA and multiple regressions, direct effects are connections between measured and latent variables. With the aid of single-directional arrows, we visually represent them. When one or more latent variables mediate the relationship between an independent latent variable and a dependent latent variable, this is referred to as an indirect effect [154]. The latent and measurable variables are either exogenous (independent) or endogenous (dependent). According to classical test theory, true scores and errors make up any observed measure's variance. Compared to unreliable measurements, reliable measures have less error and are thought to better indicate the underlying construct. SEM takes this presumption into account when estimating error variance for dependent variables. The assumption is that the latent variable cannot fully explain the variance of the dependent variables; hence error variance must also be modeled.

Steps in SEM: Data collection, model formulation, identification, estimation, evaluation, and modification are the six stages that must be completed in order to test the model [155,156]. The process of model specification involves identifying the links between the observable and latent variables that are hypothesized to exist or not. Since any unspecified associations between variables are presumed to be equal to zero, this distinction is crucial. We must take model identification into account before we analyze the data. SEM, like factor analysis, aims to identify the most precise description of the interrelationships among variables that faithfully capture the associations found in the data.

Researchers are now at the stage of estimating the model after defining the model, confirming that the model is identifiable, gathering data from a sufficient sample of participants, and fixing any issues with the data. The estimation process includes calculating the values of the unknown parameters and the error surrounding those values. Researchers include both standardized and non-standardized parameter values, or coefficients, as output, similar to regression. In regression, the unstandardized coefficient is comparable to a B weight. The z value that results from dividing the unstandardized coefficient by the standard error is comparable to the t value assigned to each B weight in regression. The standardized coefficient is equivalent to regression. Maximum Likelihood (ML), Least Squares (LS), Unweighted LS, Generalized LS, and Asymptotic Distribution Free (ADF) are some estimation techniques. Prior to beginning their analysis, researchers must decide which estimating technique to employ. Whether the data have a normal distribution is one deciding aspect. In contrast to ML and modified LS approaches, LS and ADF do not assume multivariate normality. When the sample is large enough, ADF does this instead of LS estimation, which is unable to make a reliable inference about the population from the sample. One of the most widely used methods, ML, is resilient to mild normality assumption deviations [157], and when data are mildly non-normal, many researchers choose to employ ML.

The model's fit to the data must be assessed after estimation. The goal is to ascertain whether or not the estimated model's relationships between measurable and latent variables appropriately reflect the associations that were seen in the data. There are numerous indices available to assess the model fit.

1. Absolute fit indices: These includes the goodness-of-fit index (GFI), chi-square, root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR).

GFI: This index assesses how much of the empirical covariance matrix's variances and covariance are predicted by the covariance matrix implied by the model [158,159]. Testing how much better the model fits in comparison to "no model at all" is implied by this. Higher numbers indicate better fit, and the GFI normally ranges between 0 and 1; however, a negative GFI can occasionally occur. The standard rule of thumb for this index is that values more than 0.90 are typically regarded as an acceptable fit, while values of 0.95 are suggestive of a good fit relative to the baseline model [160].

Chi-square: In practice, testing for model misspecification, Chi-square ($\chi 2$) and scaled $\chi 2$ [161] values are used. The model does not fit the sample data, according to a significant $\chi 2$ result. A non-significant $\chi 2$, on the other hand, indicates that the model adequately matches the data.

RMSEA: The RMSEA is concerned with the discrepancy resulting from approximation because it measures approximate fit in the population [162,163]. When two models are equally effective in explaining the observed data, the simpler model will have a lower RMSEA value. The model perfectly fits the data when the RMSEA value is 0.00. A more recent trend is providing the 90% confidence interval (CI), which accounts for the sampling error connected to the predicted RMSEA.

SRMR: Covariance residuals provide the foundation of the SRMR index [164], with smaller values indicating a better fit. The SRMR summarizes the divergence between the observed data and the model. A mean of zero means no difference between the observed data and the correlations suggested by the model; hence, an SRMR of 0.00 means that the model is perfectly fitted.

2. Incremental fit index: Incremental fit index includes adjusted goodness-of-fit-index (AGFI), comparative fit index (CFI), normed fit index (NFI), and Tucker-Lewis Index (TLI) [152].

AGFI: The Adjusted Goodness-of-Fit Index (AGFI) was created to account for a bias brought by model complexity [158]. The AGFI promotes less complex models with fewer parameters since it considers the model's degrees of freedom about the number of observable variables.

CFI: This metric measures how well the researcher's model fits the data compared to a more constrained model known as the independence or null model, which states that there are no correlations between the variables [160,165]. CFI ranges from 0 to 1.0, with values nearer 1.0 suggesting greater fit.

NFI: The Normed Fit Index (NFI) analyzes the discrepancy between the chi-squared value of the hypothesized model and the chi-squared value of the null model [166]. Higher values denote better fit, while NFI values range from 0 to 1. According to the standard rule of thumb for this index, a value greater than.90 is often read as indicating an acceptable fit. In contrast, a value of 0.95 suggests a strong fit compared to the baseline model [167]. The NFI has the drawback of being influenced by sample size [168].

TLI: To overcome the problem of NFI, The Tucker-Lewis Index (also known as the Non normed Fit Index, or NNFI) was created by Tucker and Lewis [166,169]. A general guideline for this index is that values more than 0.95 may be considered an acceptable fit, while values greater than 0.97 suggest a good fit to the independence model.

Modifying the estimated model indicates either releasing (estimating) or setting (not estimating) the parameters. Modification is a contentious subject that has been compared to the discussion surrounding post hoc comparisons in an ANOVA. In order to determine which modifications lead to a better-fitting model, researchers typically modify by applying statistical search tactics (commonly referred to as a specification search). The Lagrange Multiplier test reveals which variables the researcher thought to be zero are significantly different from zero and need to be approximated. The Wald test, however, determines which estimated parameters that were thought to be substantially different from zero are actually not and which ones should be dropped from the model [156].

In the present study, we applied CFA and ensured the requirements of model fit indices to measure the model's validity. In summary, the conditions are chi-square index by the degree of freedom ($\chi 2$ /df) must be lower than 3.0, goodness-of-fit index (GFI), incremental fit index (IFI), normed fit index (NFI), Tucker-Lewis index (TLI) and comparative fit index (CFI) must all be greater than 0.90 and root means square error of approximation (RMSEA) must be lower than 0.08 (Hair et al., 2009; Schermelleh-Engel et al., 2003). Standardized factor loading (minimum threshold 0.50), Cronbach's alpha coefficient, composite reliability (CR) both with a minimum threshold of 0.70, and average variance extracted (AVE) with a minimum threshold of 0.50 indicates the convergent validity [146,151,170]. To determine discriminant validity, the AVE square root should be bigger than the correlation between that item and the other components in the equation [149,170].

3.3 Results

3.3.1 Descriptive analysis

This study aimed to investigate the relationships between social, psychological, and behavioral traits and the water-conservation practices of international students and employees residing in Japan. Table 3.1 lists the descriptive traits of the participants. Participants were mostly men (58%), aged 18 to 24 (33.3%), and 58.5% were from Asian countries, with 25.2% coming from Europe/America. Additionally, the majority of participants reported a more positive attitude

(40.8%), higher water-related awareness (41.3%), responsibility to conserve water (37.9%), a conservation habit (38%), and a favorable emotion about conserving water (34.7%). 33.1% of participants said their families practiced water conservation, while 36.3% said they actively practiced it. A neutral level of personal involvement in the conservation effort was, however, reported by 34.3% of respondents.

Table 3.1: Descriptive analysis of participants (international students and employees)

Descriptive	Categories	Frequencies	Percentages
Gender	Male	363	58
	Female	262	42
Age	18-24	138	22
	25-31	208	33.3
	32-38	164	26.2
	39-45	115	18.4
Region	Asia	366	58.5
	Europe/America	157	25.2
	Africa	102	16.3
Awareness	Strongly disagree (1)	48	7.7
Mean=3.97	Disagree	77	12.3
SD=0.64	Neutral	125	20
	Agree	258	41.3
	Strongly agree (5)	117	18.7
Attitude	Strongly disagree (1)	37	5.9
Mean=4.16	Disagree	55	8.8
SD=0.62	Neutral	100	16.1
	Agree	255	40.8
	Strongly agree (5)	178	28.4
Responsibility	Strongly disagree (1)	41	6.6
Mean=4.42	Disagree	82	13.1
SD=0.63	Neutral	102	16.3

Table 3.1 continued

	Agree	237	37.9
	Strongly agree (5)	163	26.1
Household culture	Strongly disagree (1)	47	7.5
Mean=3.88	Disagree	81	13
SD=0.72	Neutral	133	21.3
	Agree	207	33.1
	Strongly agree (5)	157	25.1
Involvement	Strongly disagree (1)	54	8.6
Mean=3.42	Disagree	98	15.7
SD=0.80	Neutral	214	34.3
	Agree	149	23.8
	Strongly agree (5)	110	17.6
Emotion	Never (1)	21	3.4
Mean=4.22	Sometime	89	14.2
SD=0.87	Half the time	131	21
	Most of the time	217	34.7
	Always (5)	167	26.7
Water use Habit	Never (1)	19	3
Mean=4.01	Sometime	99	15.8
SD=0.77	Half the time	127	20.3
	Most of the time	237	38
	Always (5)	143	22.9
Behavior	Strongly disagree (1)	17	2.7
Mean=4.18	Disagree	64	10.2
SD=0.76	Neutral	113	18.1
	Agree	227	36.3
	Strongly agree (5)	203	32.5

Participants were asked to respond to a multiple-choice question about the most crucial aspect of water conservation and to express their opinion on the influence of water pricing on water-saving behavior (Fig. 3.2). The findings showed that 38.6% of participants thought that knowledge of water concerns was the most important component, while 20.2% believed that a positive attitude was the most critical factor. Additionally, 69.1% of participants agreed with the assertion that water price has an impact on water use and water-saving behavior.

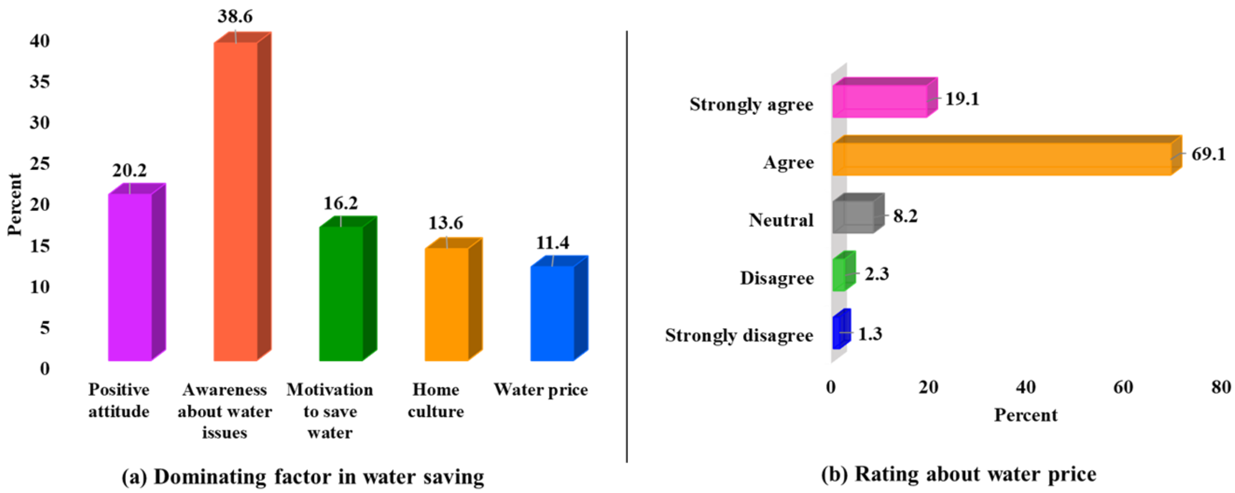

Fig. 3.2 (a) Most dominating factor in water-saving (b) Water price influences the amount of water use and water-saving behavior

3.3.2 Analysis of measurement model and structural model

Confirmatory factor analysis (CFA) had excellent and reasonable model fit indices. The model fit indices were: $\chi 2$ /df = 2.89, goodness-of-fit-index (GFI)= 0.90, normed fit index (NFI) = 0.92, incremental fit index (IFI) = 0.91, comparative fit index (CFI) = 0.92, Tucker-Lewis index (TLI) = 0.93, root mean square error of approximation (RMSEA) = 0.071. Additionally, all items had average variance extracted (AVE) values between 0.50 and 0.64, standardized factor loading values greater than 0.50, composite reliability (CR) values between 0.80 and 0.86, and Cronbach's alpha values between 0.78 and 0.84, all of which were higher than the required recommended values. The models were discovered to show convergent validity for the variables. The Pearson correlation test was employed to assess the relationship between the constructs. The findings showed that all constructs had a strong relationship (Table 3.2). Furthermore, each AVE item's square root score was higher than the correlations between that item and others, demonstrating the achievement of discriminant validity.

Table 3.2: Results of Confirmatory factor analysis and Correlation test

Constructs	Awareness	Attitude	Responsibility	Culture	Involvement	Emotion	Water use habit	Behavior
Awareness	1							
Attitude	0.39**	1						
Responsibility	0.41**	0.37**	1					
Culture	0.35**	0.24**	0.29**	1				
Involvement	0.22**	0.33**	0.33**	0.33**	1			
Emotion	0.25**	0.46**	0.38**	0.25**	0.17**	1		
Water use habit	0.36**	0.34**	0.27**	0.25**	0.19**	0.43**	1	
Behavior	0.37**	0.48**	0.25**	0.20**	0.30**	0.30**	0.28**	1
Cronbach's alpha	0.82	0.79	0.82	0.78	0.79	0.84	0.81	0.80
AVE	0.54	0.57	0.53	0.51	0.50	0.60	0.64	0.51
CR	0.83	0.81	0.84	0.80	0.80	0.86	0.83	0.81
Square root of AVE	0.73	0.75	0.72	0.71	0.71	0.77	0.80	0.71

Significant at **p<0.05

Once the measurement models were confirmed, the structural model was used to test the study hypotheses.

The structural (latent variable) model used in this study is as follows:

$$Attitude = a_1 + b_1 Awarenes + \epsilon_1$$

$$Responsibility = a_2 + b_2 Awareness + \epsilon_2$$

$$Culture = a_3 + b_3\,Awareness + \epsilon_3$$

$$Habit = a_4 + c_1 Culture + \epsilon_4$$

$$Emotion = a_5 + c_2 Culture + d_1 Responsibility + e_1 Attitude + \epsilon_5$$

$$Involvement = a_6 + f_1 Emotion + \epsilon_6$$

$$Behavior = a_7 + c_3 Culture + g_1 Habit + f_2 Emotion + h_1 Involvement + \epsilon_7$$

Where, a_i indicates the intercepts; $b_i, c_i, d_i, e_i, f_i,\ g_i, and\ h_i$ represents the regression coefficients of awareness, culture, responsibility, attitude, emotion, habit, and involvement; and ϵ's are the random errors.

The outcomes of the structural model were similarly good. The model fit indices were found to be $\chi2/df = 2.76$, GFI = 0.91, NFI = 0.92, IFI = 0.92, CFI = 0.94, TLI = 0.92, RMSEA = 0.064. The model explained 46% of the variance in water-saving practices (Fig. 3.3). There was a significant positive relationship between awareness and attitude ($\beta = 0.29$, $p < 0.01$), responsibility ($\beta = 0.41$, $p < 0.01$), and culture ($\beta = 0.17$, $p < 0.05$). Moreover, attitude ($\beta = 0.38$, $p < 0.01$) and responsibility ($\beta = 0.26$, $p < 0.01$) had a significant positive association with emotion. However, there was no statistically significant correlation between culture and emotion ($\beta = 0.10$, $p = 0.182$). Furthermore, Culture was significantly related to habit ($\beta = 0.12$, $p < 0.05$), and emotion was significantly related to involvement ($\beta = 0.17$, $p < 0.05$). Finally, there was a statistically significant positive correlation among involvement ($\beta = 0.09$, $p < 0.05$), emotion ($\beta = 0.17$, $p < 0.01$), habit ($\beta = 0.23$, $p < 0.01$), and culture ($\beta = 0.16$, $p < 0.01$) with water conservation behaviors. All study hypotheses were evaluated using a path coefficient estimation, and the results showed that all but H6 were confirmed (Table 3.3).

Compared to past study findings on water-saving behaviors, the proposed model's prediction power was significant and sufficient [11,28,63,171].

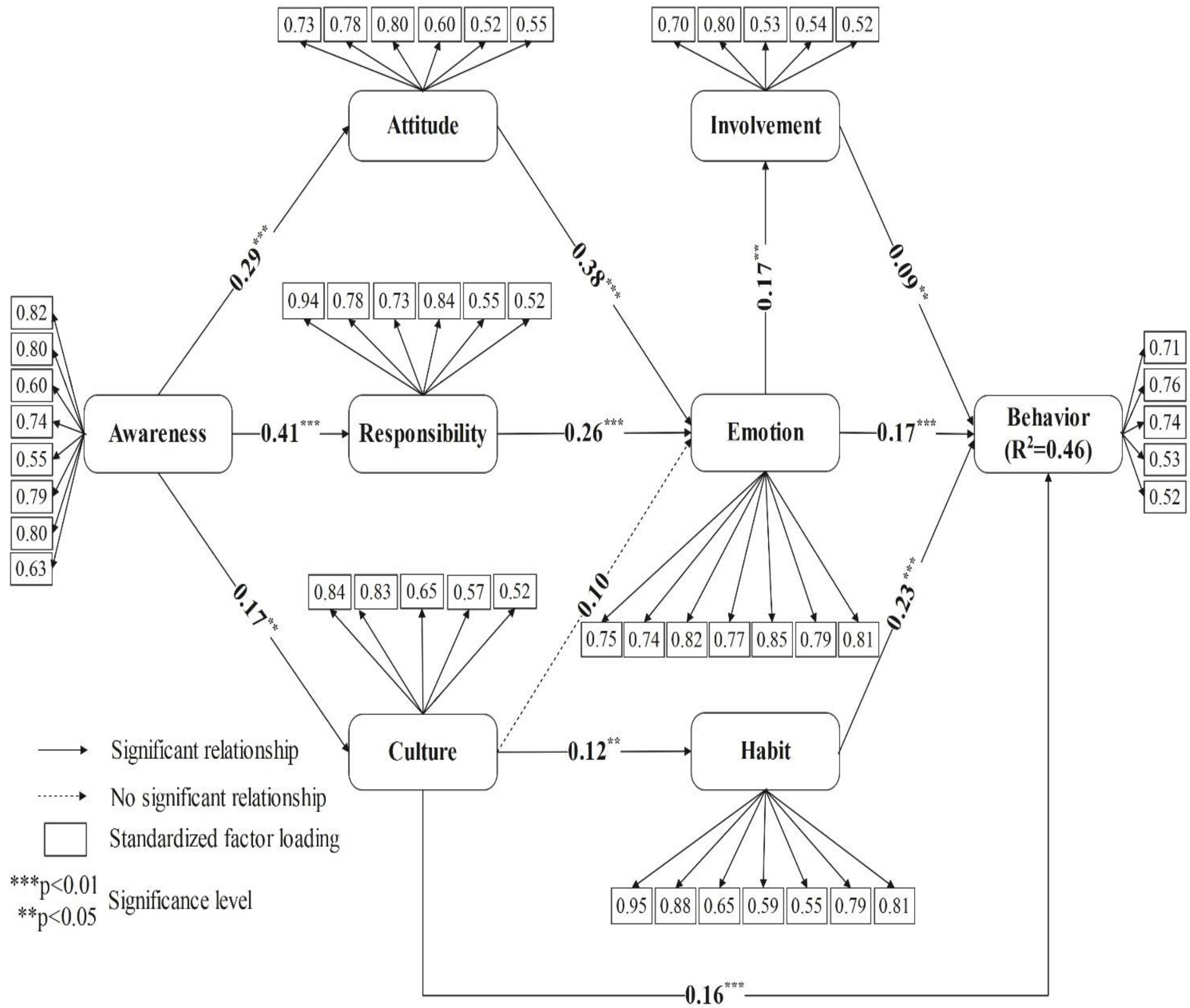

Fig. 3.3 The structural model through standardized estimates (relationship among latent variables or contsructs)

Table 3.3: Hypotheses testing (H_1 - H_{12}) by Structural equation modeling

Hypothesis		Standardized coefficients	t-values	95% confidence interval	Decision
H_1: Awareness	→ Attitude	0.29	6.74***	(0.203, 0.369)	Supported
H_2: Awareness	→ Responsibility	0.41	10.83***	(0.334, 0.481)	Supported
H_3: Awareness	→ Culture	0.17	3.79**	(0.083, 0.261)	Supported
H_4: Responsibility	→ Emotion	0.26	5.81***	(0.171, 0.346)	Supported
H_5: Attitude	→ Emotion	0.38	8.99***	(0.297, 0.463)	Supported
H_6: Culture	→ Emotion	0.10	-1.64	(0.023, 0.152)	Not supported
H_7: Culture	→ Habit	0.12	-1.75**	(0.033, 0.176)	Supported
H_8: Emotion	→ Involvement	0.17	3.68**	(0.077, 0.253)	Supported
H_9: Emotion	→ Behavior	0.17	3.51***	(0.073, 0.259)	Supported
H_{10}: Involvement	→ Behavior	0.09	1.93**	(-0.001, 0.176)	Supported
H_{11}: Habit	→ Behavior	0.23	4.83***	(0.135, 0.320)	Supported
H_{12}: Culture	→ Behavior	0.16	3.67***	(0.076, 0.249)	Supported

Significant at ***$p<0.01$ and **$p<0.05$

The 5-fold cross-validation method was utilized in the current study to ensure the model's robustness. First, the dataset was divided into five folds. In the initial iteration, the first fold served as a test dataset, while the subsequent folds served as a training dataset. The second iteration used the training dataset from the remaining folds and the second fold as the test dataset. This procedure was repeated until every fold was utilized as the test dataset. The details are shown in Fig. 3.4. In each cycle, we estimated and compared the root mean square error of approximation (RMSEA) for the two datasets. Table 3.4 presents each RMSEA. The training and test dataset’s RMSEA values were close, proving the model's validity.

Dependent variable: Water conservation behavior

Table 3.4: Root mean square error of approximation (RMSEA) value of training data and test data for cross-validation

Fold	Root mean square error of approximation (RMSEA)	
	Training data	Test data
1	0.068	0.070
2	0.065	0.067
3	0.069	0.071
4	0.067	0.066
5	0.070	0.071

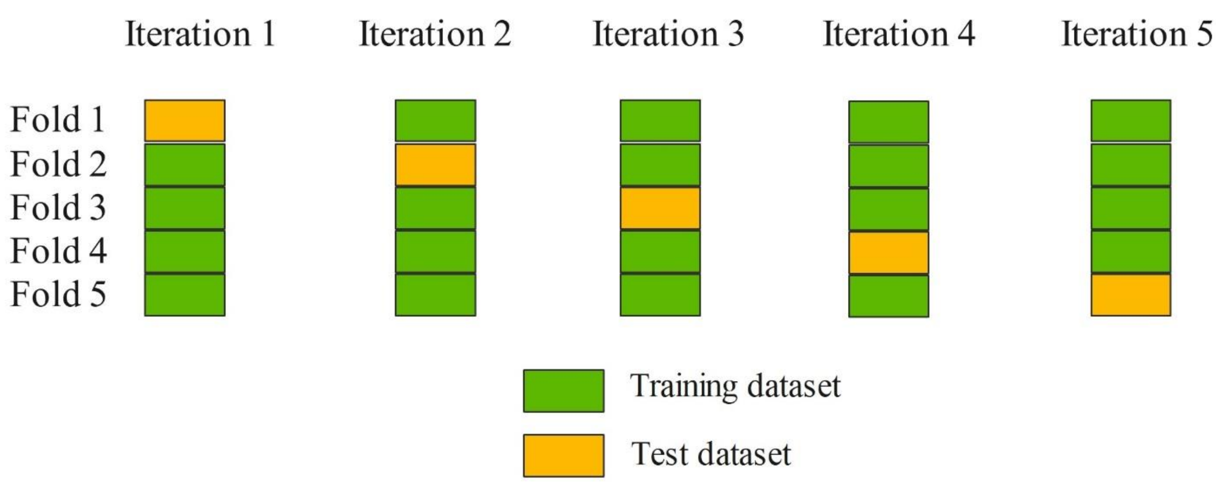

Fig. 3.4 A 5-Fold cross-validation approach

3.3.3 Regression model

A multiple regression model was used to investigate the impact of gender, age, and location on social, psychological, and behavioral aspects, as well as conservation behavior (Table 3.5). Results revealed that, aside from awareness of water issues and participation in any educational or training programs, female participants exhibited a substantially higher positive attitude, emotion, and behavior toward water-saving compared to male participants. Participants who were older than the age range of 18 to 24 were exposed to a culture of water conservation that was substantially stronger and had higher levels of awareness and conservation behavior. Additionally, participants from European and American countries had statistically significantly greater levels of positivity, responsibility, habit, emotion, and culture than those from other locations.

Table 3.5: Multiple regression analysis (the effect of demographic variables on psychological, social and behavioral factors)

Variables	Awareness Estimate	Attitude Estimate	Responsibility Estimate	Culture Estimate	Involvement Estimate	Emotion Estimate	Water use habit Estimate	Behavior Estimate
Gender								
Male (ref)								
Female	-0.622 (0.081)	0.652** (0.013)	0.041 (0.875)	0.142 (0.575)	-1.728*** (0.000)	1.415*** (0.002)	0.313 (0.391)	0.848*** (0.000)
Age								
18-24 (ref)								
25-31	1.246** (0.011)	0.094 (0.786)	0.574 (0.098)	0.178 (0.596)	0.658 (0.130)	0.074 (0.902)	2.148*** (0.000)	1.363 *** (0.000)
32-38	1.277** (0.013)	0.393 (0.284)	0.129 (0.723)	2.422*** (0.000)	-0.809 (0.078)	0.674 (0.288)	1.049** (0.041)	1.523*** (0.000)
39-45	1.226** (0.035)	0.619 (0.136)	0.255 (0.537)	1.971*** (0.000)	-0.576 (0.266)	0.012 (0.987)	1.263** (0.030)	1.752*** (0.000)
Region								
Asia (ref)								
Europe/ America	0.203 (0.665)	1.041** (0.020)	0.771** (0.022)	0.730** (0.025)	0.119 (0.776)	.381 (0.281)	1.307*** (0.006)	0.394 (0.176)
Africa	0.706 (0.147)	-0.041 (0.902)	0.169 (0.627)	0.612 (0.070)	-0.071 (0.869)	0.622 (0.302)	0.824 (0.091)	-0.043 (0.887)

Significant at *** $p<0.01$ and ** $p<0.05$, p-values are presented in parentheses

Sequential regression analysis was also carried out to ensure the robustness of the results. Demographic factors (gender, age, and location) accounted for 13% of the variation in water conservation behavior at the model's initial step (Table 3.6). The addition of social variables significantly increased the variation in water conservation at 32%. Moreover, the degree of variation (48%) in water-saving behavior significantly increased when psychological variables were added to the model. By integrating habit as a behavioral feature in the model at the end of the study, the variation in conservation behavior is significantly increased to 53%. Interestingly, involvement and culture came out to be the least significant predictors once the behavioral factor (habit) was added, indicating that the impact of involvement and culture was moderated by habit. The Sobel tests for mediation were significant for involvement (z = 2.27, p < .001) and culture (z = 4.16, p < .001).

Table 3.6: Sequential regression analysis (stepwise integration of demographic, social, psychological and behavioral factors)

Predictors	Stage 1 *F*(6, 618)=8.81 Estimate	Stage 2 *F*(9, 615)=12.26 Estimate	Stage 3 *F*(12,612)=12.36 Estimate	Stage 4 *F*(13,611)=11.77 Estimate
Gender				
Male (ref)				
Female	0.848^{***} (0.000)	0.701^{***} (0.002)	0.532^{**} (0.015)	0.537^{**} (0.014)
Age				
18-24 (ref)				
25-31	1.363^{***} (0.000)	1.631^{***} (0.000)	1.552^{***} (0.000)	1.405^{**} (0.035)
32-38	1.523^{***} (0.000)	1.751^{***} (0.000)	1.727^{**} (0.045)	1.614^{**} (0.047)
39-45	1.752^{***} (0.000)	1.921^{***} (0.000)	1.740^{**} (0.037)	1.635^{**} (0.041)
Region				
Asia (ref)				
Europe/ America	0.394 (0.176)	0.506 (0.070)	0.581^{**} (0.036)	0.474 (0.091)
Africa	-0.043 (0.887)	0.043 (0.880)	0.095 (0.734)	0.034 (0.902)
Social factors				
Awareness		0.145^{***} (0.000)	0.116^{***} (0.000)	0.103^{***} (0.001)
Responsibility		0.111^{**} (0.010)	0.123^{***} (0.001)	0.091^{**} (0.042)
Involvement		0.135^{**} (0.028)	0.125^{**} (0.013)	0.029 (0.348)
Psychological factors				
Attitude			0.265^{***} (0.000)	0.258^{***} (0.000)
Emotion			0.164^{**} (0.013)	0.168^{**} (0.039)
Culture			0.081^{**} (0.049)	0.037 (0.443)
Behavioral Factors				
Water use habit				0.079^{**} (0.043)
Adjusted R^2	0.13	0.32	0.48	0.53

Significant at $^{***}p<0.01$ and $^{**}p<0.05$, p-values are presented in parentheses

3.4 Discussion

Recognizing the need for water conservation and understanding how to use less water is the first step in a household implementing a water conservation strategy. In order to make decisions on water conservation, it is crucial to be informed of water issues, including water demand and the water crisis. Consistent with earlier research, the findings from structural equation modeling of the present study showed that awareness had a substantial positive correlation with responsibility, attitude, and culture toward water conservation [29,33,35,61,172,173]. People are more likely to engage in water-saving actions if they believe they are required to do so and are beneficial. The results of this study show that those who feel more responsible and have a good attitude show more positive sentiments toward water conservation and engage in more conservation activities. Participants who expressed greater responsibility, understanding of water issues, and participation in any conservation program used less water overall [3,32]. In addition, this research supported earlier findings that involvement, emotion, culture, and habits were all associated with water conservation efforts in a good way [32,42,66,125,174]. The likelihood of participants engaging in water conservation was higher when they reported having a good attitude, emotion, and culture toward it. According to certain prior studies, households with a higher water-saving culture and optimistic outlook used less water [24,28,65]. Water-saving households adopted greater water-saving behaviors because of their personal water culture [6]. As predictors of environmental engagement, emotions are now more widely acknowledged. Existing research demonstrates that emotions significantly influence the likelihood of environmental involvement [65,80]. Habits, according to Ajzen [43,175] are behaviors that are recurrently performed and contain minimum effort as well as have a direct influence on water-saving. Habits can positively affect people's intentions to conserve water, particularly if they consider conservation to be a way of life and actively seek out opportunities to participate in water-saving activities on a daily basis [176]. Participants who reported more habitual behavior were also more likely to indicate water-saving practices that had been proven in earlier studies [43,175].

Furthermore, it was notable from the sequential regression analysis that female participants exhibited higher positive attitudes, emotions, and water conservation behavior than male participants [19]. Compared to younger individuals, older participants showed higher levels of awareness, habit, culture, and water conservation behavior [6,28]. Participants from European and American regions had more water-saving attitudes, practices, and cultures than participants from other locations. Participants also responded that awareness of water issues was the most important factor influencing their water-saving behavior. They added that water costs or prices directly impact individuals' water-saving practices.

3.5 Conclusion

The purpose of the first project (international students and employees) was to identify the important variables of water-saving behavior in order to understand better which factors may be addressed in water demand reduction campaigns. The role of demographic, social, psychological, and behavioral variables, as well as their interaction with an objective measure of water conservation, were thus thoroughly explored in this study. The structural equation model's findings revealed a substantial relationship between awareness of water concerns, attitudes, responsibilities, and cultural readiness to practice water conservation activities. The results also showed that, except culture, these factors were significantly related to feelings about water consumption. Finally, it was discovered that behavior linked to water conservation was favorably and greatly influenced by emotion, habit, culture, and engagement. The suggested model explained a 46% variation in the water conservation practices of international employees and students from various universities residing in Fukuoka, Japan. In the sequential regression model, demographic factors (gender, age, and location) explained 13% of the variation in water-saving behavior. The proportion of variation explained (32%) in water conservation dramatically increased by including social variables. When psychological factors were considered, the model's explanatory power jumped considerably to 48%. Last but not least, adding habit as a behavioral factor considerably increased the model's ability to account for 53% of the variation in conservation behavior. Intriguingly, participation and culture were found to be minor predictors after controlling for the behavioral factor (habit), suggesting that the influence of involvement and culture was mediated by habit.

Chapter 4

Water Consumption and Conservation Behavior of Japanese people

4.1 Research Hypotheses

The conceptual framework for the current investigation (second project) is shown in Figure 4.1. Based on the discussions stated above, the following hypotheses are being examined. We anticipate that awareness will be a direct predictor of attitude (H_1), responsibility (H_2), emotion (H_3), habit (H_4), and involvement (H_5). Then, the two main emotional aspects influencing water conservation and consumption are attitude (H6) and responsibility (H7). The immediate indicators of habit and involvement would be attitude (H8) and responsibility (H9), respectively. Finally, emotion (H_{10}), habit (H_{12}), and involvement (H_{14}) would be strongly and favorably associated with water conservation behavior and negatively with the quantity of water consumption (H_{11}, H_{13}, and H_{15}).

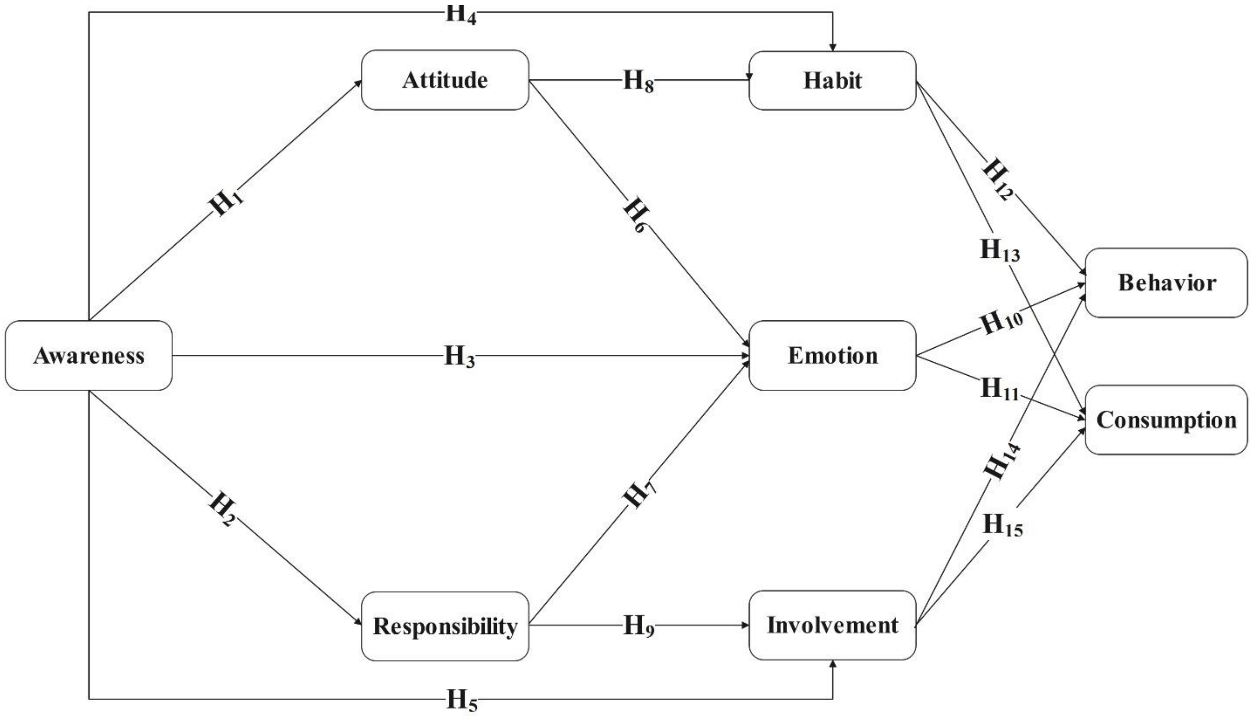

Fig. 4.1 The conceptual outline of the research on water consumption and conservation behavior of Japanese people

4.2 Empirical Methods

4.2.1 Data collection and measures

A questionnaire survey method was used to collect data and test the research hypotheses. Data were collected between September and October of 2021, considering a final sample of 514 people aged 18 to above 65. The research sample was drawn from households in Fukuoka Prefecture, Japan, using a stratified random sampling technique by the Macromill survey company. Gender was used to create strata. The total number of households in Fukuoka prefecture was split into two groups based on gender, resulting in two strata. From each stratum, 257 households (total = 2*257=514) were selected using a simple random sampling approach, and then the household head was interviewed to obtain data. Since it is challenging to find information on individual water consumption, we use household-level water consumption data to investigate the approximate impact of socio-psychological factors on their water consumption.

To address the topic of the current study, we designed measurement instruments built on an in-depth review of earlier published research (Described in chapter 3). All the relevant measures have been validated in previous research in a variety of contexts. The questionnaire's face validity was then tested by distributing paper copies to randomly 25–30 laypeople. After a few changes, the final questionnaire contained 42 acceptable items scored on a five-point Likert response scale ranging from “1 = strongly disagree/never” to “5 = strongly agree/always”.

To measure the amount of water consumption, we collect every respondent's average water bill for the last six months. From the water bill, we estimate the amount of water used. Water consumption was derived from household water bills considering the water price structure according to household income. In Fukuoka prefecture, there is little variation in water prices according to the income of the household. We have collected information on the water price structure from Fukuoka prefectural government and measured water consumption from household water bills based on the water price structure. We also collect demographic information including gender, age, education, occupation, current living status (dormitory/rented house/own house), types of houses (detached/apartment), number of rooms and family members, and income level. The Appendices provide a list of constructs and measuring items in the Japanese language.

4.2.2 The method of analysis

The structural equation modeling (SEM) method was used to test the hypothesized associations between the study constructs and to quantify the direct and indirect impact of psychological, social, and behavioral determinants influencing consumption and conservation actions. The analysis was carried out using STATA 16. SEM is a statistical approach that uses latent variables (factors or constructs) to describe theoretical ideas and then combines them to explore their interactions [146]. The estimation of two models, the measurement model, and the structural model, are required for SEM analysis [150,151]. Observed measures and latent constructs are investigated using the measurement model, whereas construct associations and specific research hypotheses are tested using the structural model. Consequently, the present study estimated the measurement model by CFA (Confirmatory Factor Analysis), and then the structural model was used to test the research hypotheses. The detail structural model is presented below:

The structural (latent variable) model used in this study as follows:

$$Attitude = a_1 + b_1 Awarenes + m_1' X + \epsilon_1$$

$$Responsibility = a_2 + b_2 Awareness + m_2' X + \epsilon_2$$

$$Habit = a_3 + b_3 Awareness + c_1 Attitude + m_3' X + \epsilon_3$$

$$Emotion = a_4 + b_4 Awareness + c_2 Attitude + d_1 Responsibility + m_4' X + \epsilon_4$$

$$Involvement = a_5 + b_5 Awareness + d_2 Responsibility + m_5' X + \epsilon_5$$

$$Behavior = a_6 + e_1 Habit + f_1 Emotion + g_1 Involvement + m_6' X + \epsilon_6$$

$$Consumption = a_7 + e_2 Habit + f_2 Emotion + g_2 Involvement + m_7' X + \epsilon_7$$

Where, a_i indicates the intercepts; $b_i, c_i, d_i, e_i, f_i, and\ g_i$ represents the regression coefficients of awareness, attitude, responsibility, habit, emotion, and involvement; X=vector of control variables (income, occupation, education, house ownership, gender, no. of rooms, and family size); m_i' represents the regression coefficients of control variables; and ϵ's are the random errors. The indirect effects are calculated using the product of coefficients approach [177].

Confirmatory factor analysis was also used in the second project to evaluate the reliability, validity, suitability, and quality of the measurement models. In this respect, the requirements were: The minimum acceptable threshold for chi-square by degrees of freedom (χ2 /df) should be less than 3.0, The acceptable levels for standardized root mean square residual (SRMR), and the root mean square error of approximation (RMSEA) must be below 0.08 and 0.06, respectively and the goodness-of-fit index (GFI) and the normed fit index (NFI) with values above 0.90, as well as the comparative fit index (CFI) and the Tucker-Lewis index (TLI) with values greater than 0.95 all suggesting the acceptable fit model [151,155,156]. The details about these requirements are already illustrated in chapter 3.

We also computed Composite Reliability (CR) and Cronbach's alpha which must be greater than 0.70 [151]. The average variance explained by a construct is referred to as AVE [151], and a construct's and an indicator's association is known as factor loading [151,156]. To assess discriminant validity, the AVE value for each construct should be greater than the square of its correlation with the other constructs. [150,151,170].

Ordered Logistic Regression Model

The dependent variable used in this study has natural ordering. For example, the opinion regarding water conservation, “I am highly passionate about water conservation” may strongly disagree, disagree, neutral, agree, and strongly agree. We can code 1 for " strongly disagree," 2 for " disagree," 3 for " neutral," 4 for " agree," and 5 for " strongly agree " for such categories. The distinction between categories 2 and 3 does not have to be the same as the distinction between categories 4 and 5. The values are not quantitative here, but they do have a natural order. For the estimate of an ordinal dependent variable, ordered logistic regression is commonly used [178,179].

For the ordinal dependent variable, several models have been investigated in the literature; the main goal of ordered logit models is to determine the accumulative probability of higher than the j^{th} category for the dependent variable [180–184]. McCullagh [185] refers to this model as the proportional odds model (POM), which assumes that the effect of the predictor variable is the same for all response variable categories. This assumption is also known as the proportional odds assumption or parallel lines assumption.

The likelihood of outcome variable Y with P categories being less than or equal to a category j can be described by the logistic distribution with a collection of predictors X having the effect parameters δ as follows

$$\beta_j = \Pr\left(Y \le y_j \middle| X\right)$$

$$\Pr\left(Y \le y_j \middle| X\right) = \frac{\exp\left[\alpha_j - \left(\delta_1 X_{i1} + \delta_2 X_{i2} + ...+ \delta_k X_{ik}\right)\right]}{1+\exp\left[\alpha_j - \left(\delta_1 X_{i1} + \delta_2 X_{i2} + ...+ \delta_k X_{ik}\right)\right]}$$

where $j = 1,2,3,....,P-1$

The cumulative probability β_j of category j is provided by the aforementioned model, and we calculate the $P-1$ cumulative probabilities for the predictors with categories P.

The proportional odds model shown above can also be written as

$$\Pr\left(Y \le y_j \middle| X\right) = \frac{1}{1+\exp\left[-\alpha_j + \left(\delta_1 X_{i1} + \delta_2 X_{i2} + ...+ \delta_k X_{ik}\right)\right]}$$

The odds of response variable falling into category j to category greater than j can be represented as

$$\frac{\Pr\left(Y \le y_j \middle| X\right)}{\Pr\left(Y > y_j \middle| X\right)} = \exp\left[\alpha_j - \left(\delta_1 X_{i1} + \delta_2 X_{i2} + ... + \delta_k X_{ik}\right)\right]$$

The logit model, which is the linear function of K predictors, may be written as the natural log of odds ratio.

$$Log\left[\frac{\Pr\left(Y \le y_j \middle| X\right)}{\Pr\left(Y > y_j \middle| X\right)}\right] = \alpha_j - \left(\delta_1 X_{i1} + \delta_2 X_{i2} + ... + \delta_k X_{ik}\right)$$

Here, α_j are the intercepts and $\delta_1, \delta_2, ..., \delta_k$ the coefficient of predictors.

4.3 Results

4.3.1 Descriptive analysis

The purpose of the current research was to assess the relationship among psychological, social, and behavioral characteristics with water consumption and conservation behavior. The descriptive features of the participants are presented in Table 4.1. Among them, 50% were male, and the average age was 46. Moreover, most of the participants reported a higher level of positive attitude (41.7%), greater understanding of water issues (41.4%), responsibility to conserve water (51.9%), conservation habits (58.3%), and favorable emotion toward water-saving (49.0%), and 43.6% engaged in conservation performance. 34.7 percent of respondents, on the other hand, had some personal involvement in the conservation effort. Besides, the average amount of consumption was found to be 19.4 m^3.

Table 4.1: Descriptive statistics of the participants (Japanese people)

Descriptive	Categories	Frequencies	Percentages
Gender	Male	257	50.0
	Female	257	50.0
Income	< 2 million	41	10.7
	2-4 million	126	32.9
	4-8 million	158	41.0
	>8 million	59	15.4
Occupation	Civil servant	33	6.4
	Office worker	193	37.6
	Self-employed	40	7.6
	Unemployed	133	26.1
	Part-time job	77	15.0
	Student	38	7.3
Education	High school or equivalent	213	41.4
	University	247	48.1
	Others	54	10.5
House ownership	Owned house	285	55.4
	Rent house	214	41.7
	Others	15	2.9
Awareness	Strongly disagree (1)	29	5.7
Mean=3.21	Disagree	77	15.0
SD=0.07	Neutral	154	29.9
	Agree	213	41.4
	Strongly agree (5)	41	8.0
Attitude	Strongly disagree (1)	20	3.8
Mean=3.12	Disagree	90	17.5
SD=0.06	Neutral	151	29.3

Table 4.1 continued

	Agree	214	41.7
	Strongly agree (5)	39	7.6
Responsibility	Strongly disagree (1)	11	2.2
Mean=3.74	Disagree	28	5.4
SD=0.05	Neutral	146	28.3
	Agree	267	51.9
	Strongly agree (5)	62	12.1
Involvement	Never (1)	198	38.5
Mean=1.54	Sometimes	178	34.7
SD=0.05	Most of the time	98	19.0
	Always (4)	40	7.8
Emotion	Never (1)	65	12.7
Mean=2.49	Sometime	118	22.9
SD=0.06	Most of the time	252	49.0
	Always (4)	79	15.3
Water use Habit	Never (1)	64	12.4
Mean=2.25	Sometime	111	21.7
SD=0.05	Most of the time	300	58.3
	Always (4)	39	7.6
Behavior	Strongly disagree (1)	16	3.2
Mean=3.43	Disagree	75	14.6
SD=0.07	Neutral	141	27.4
	Agree	224	43.6
	Strongly agree (5)	58	11.1
Average age		46.0	
Average number of room		3.83	
Average family size		2.51	
Average water consumption		$19.41m^3$	

4.3.2 Analysis of the measurement model

To assess the measurement model and examine the validity and reliability of the suggested model, confirmatory factor analysis was used. Due to inadequate standardized factor loadings (< 0.50; Hair et al., 2010), some items should be removed, according to the preliminary CFA results. We specifically removed 2 items from the attitude construct, and 1 item from the emotion construct, 1 item from awareness, 1 item from responsibility, 2 items from involvement, and 2 items from the conservation behavior construct. The ultimate questionnaire contained 33 suitable items. The final CFA findings showed that the proposed model suited the data reasonably well ($\chi 2/df = 2.75$; GFI = 0.93, NFI = 0.92, IFI = 0.92, CFI = 0.94, TLI = 0.94, RMSEA = 0.04; SRMR = 0.05). The Pearson correlation analysis was performed to determine the relations among all the constructs for the proposed model (Table 4.2). All the latent constructs' Cronbach's alpha values ranged between 0.78 and 0.86, and the composite reliability indices (CR) fell between 0.80 and 0.87, demonstrating reliability. The standardized factor loading for each indication was higher than the suggested cutoff point of 0.50. The AVE estimations ranged from 0.52 to 0.61 and were all greater than 0.50. As a result, convergent validity was established. The related inter-construct correlations were smaller than the square root of the AVE values. These findings demonstrated the discriminant validity (Table 4.2).

Table 4.2: Results of Confirmatory Factor Analysis for measurement model and correlation among constructs

Constructs	Awareness	Attitude	Responsibility	Involvement	Emotion	Water usage habit	Behavior
Awareness	1						
Attitude	0.435***	1					
Responsibility	0.375***	0.410***	1				
Involvement	0.227***	0.282***	0.202**	1			
Emotion	0.401***	0.467***	0.481***	0.276**	1		
Water use habit	0.484***	0.314***	0.375***	0.294**	0.436***	1	
Behavior	0.264***	0.315**	0.228***	0.223***	0.298**	0.261**	1
Cronbach's alpha	0.86	0.78	0.80	0.79	0.85	0.81	0.80
AVE	0.57	0.54	0.52	0.56	0.61	0.54	0.53
CR	0.87	0.80	0.83	0.80	0.86	0.83	0.81
Square root of AVE	0.75	0.73	0.72	0.75	0.78	0.73	0.73

Significant at ***p<0.01 and **p<0.05

4.3.3 Analysis of the structural model

Once the measurement models were verified, the structural model was employed to examine the research hypotheses. The model fit indices were as follows: $\chi 2/df = 2.81$, GFI = 0.91, NFI = 0.92, IFI = 0.91, CFI = 0.93, TLI = 0.92, RMSEA = 0.05, SRMR = 0.06. The outcomes of the structural model were reasonably good. The structural model explained 57% of the variation in water conservation practices and 55% variance in water consumption (Fig. 4.2). All variables were positively related to conservation behavior and negatively to consumption. Awareness was positively and significantly associated with attitude ($\beta = 0.40$, $p < 0.01$), responsibility ($\beta = 0.42$,

$p < 0.01$), habit ($\beta = 0.51$, $p < 0.01$), involvement ($\beta = 0.16$, $p < 0.01$) and emotion ($\beta = 0.29$, $p < 0.01$). Therefore, Hypotheses 1–5 were supported. Moreover, attitude had a significant positive association with the habit ($\beta = 0.31$, $p < 0.05$) and emotion ($\beta = 0.41$, $p < 0.01$). Furthermore, responsibility had a significant impact on emotion ($\beta = 0.68$, $p < 0.01$) but insignificant on involvement ($\beta = 0.08$). These findings validated hypotheses 6-8 except 9. Next, we verified the impact of emotion, habit, and involvement on water conservation and consumption behavior pattern (H10–15). The SEM results indicated that all the latter relationships were significant except the relationship among emotion, involvement, and consumption. Involvement ($\beta = 0.15$, $p < 0.05$), emotion ($\beta = 0.21$, $p < 0.\ 01$), and habit ($\beta = 0.26$, $p < 0.01$) were favorably and significantly connected with water conservation behavior. Besides this, habit ($\beta = -0.32$, $p < 0.05$) was negatively and significantly associated with water consumption. However, involvement ($\beta = -0.05$) and emotion ($\beta = -0.17$) were negatively related to the amount of water use but not statistically significant. A direct path coefficient estimation was utilized to assess each hypothesis (Table 4.3). Therefore, these findings verified all the hypotheses except H9, H11, and H15. The results demonstrated the suggested model's applicability in the context of household water use behavior.

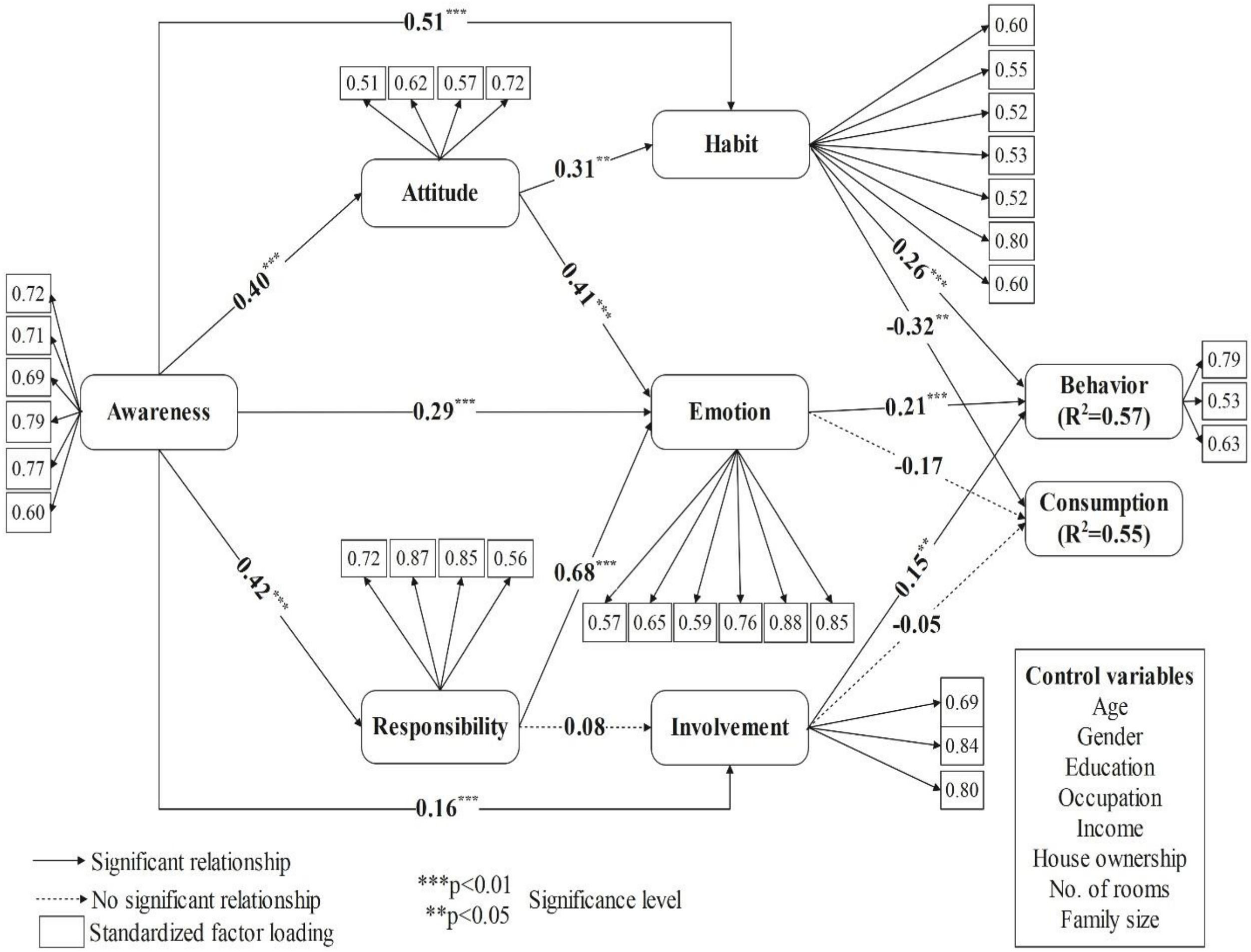

Fig. 4.2 The structural model through standardized estimation

Table 4.3: Hypotheses testing (H_1 - H_{15}) by Structural equation modeling

Hypotheses	Direct Paths	Coefficients	Standard error	p-value	Results
H_1	Awareness → Attitude	0.400***	0.022	0.000	Supported
H_2	Awareness → Responsibility	0.416***	0.026	0.000	Supported
H_3	Awareness → Habit	0.510***	0.092	0.000	Supported
H_4	Attitude → Habit	0.311**	0.163	0.057	Supported
H_5	Awareness → Emotion	0.293***	0.082	0.000	Supported
H_6	Attitude → Emotion	0.410***	0.128	0.001	Supported
H_7	Responsibility → Emotion	0.680***	0.108	0.000	Supported
H_8	Awareness → Involvement	0.158***	0.040	0.000	Supported
H_9	Responsibility → Involvement	0.078	0.065	0.224	Not Supported
H_{10}	Habit → Water conservation	0.261***	0.016	0.000	Supported
H_{11}	Emotion → Water conservation	0.212***	0.017	0.001	Supported
H_{12}	Involvement → Water conservation	0.154**	0.032	0.043	Supported
H_{13}	Habit → Water consumption	-0.320**	0.337	0.039	Supported
H_{14}	Emotion → Water consumption	-0.171	0.366	0.963	Not Supported
H_{15}	Involvement → Water consumption	-0.053	0.701	0.940	Not Supported

Significant at ***p<0.01 and **p<0.05

The indirect effects of various study variables on water conservation and consumption pattern are displayed in Table 4.4. The indirect effect of awareness through attitude was found statistically significant on habit ($\beta = .13$, $p < .05$). The effect of awareness via attitude and responsibility was also observed to be statistically significant on emotion ($\beta = .45$, $p < .01$). Besides this, attitude via habit and emotion was originated to be significant on water conservation behavior ($\beta = .02$, $p < .05$). Moreover, the indirect effect of awareness on water conservation ($\beta = .05$, $p < .01$) and consumption ($\beta = -0.25$, $p < .05$) was found statistically significant through emotion.

Table 4.4: Indirect effect of psycho-social and behavioral factors on water conservation practices and consumption

Variables	Coefficient	Std. error	p-value
Indirect Effect			
Awareness **via** Attitude → Habit	0.125**	0.065	0.048
Awareness **via** Attitude and Responsibility → Emotion	0.447***	0.068	0.000
Awareness **via** Responsibility → Involvement	-0.033	0.027	0.226
Attitude **via** Habit and Emotion → Water conservation	0.023**	0.011	0.038
Responsibility **via** Emotion and Involvement → Water conservation	0.005	0.012	0.666
Awareness **via** Emotion → Water conservation	0.052***	0.012	0.000
Attitude **via** Habit and Emotion → Water consumption	-0.124	0.150	0.409
Responsibility **via** Emotion and Involvement → Water consumption	0.007	0.262	0.977
Awareness **via** Emotion → Water consumption	-0.249***	0.250	0.030

Significant at ***$p<0.01$ and **$p<0.05$

To identify the impact of social, psychological, and behavioral factors on water conservation and consumption behavior, we also incorporated some control variables in this study (Table 4.5). The results suggest that respondents who belong to higher income levels conserve less water and use more water than low-income groups. Furthermore, compared to others, higher educated persons consume less water and engage in more water conservation activities, which is statistically significant. The findings also show that as people get older, their water-saving behavior improves, and their water use decreases. Similarly, water-saving practices also diminish, and water use increases as the number of rooms and the family expands.

Table 4.5: Effect of control (demographic and situational) variable on water conservation practices and consumption

Variables	Water conservation behavior			Water consumption		
	Coefficient	Std. error	p-value	Coefficient	Std. error	p-value
Income						
< 2 millions (ref)	0.000	-	-	0.000	-	-
2-4 millions	-0.324	0.362	0.371	7.425	8.121	0.361
4-8 millions	-0.065	0.374	0.061	3.701	8.392	0.059
>= 8 millions	-0.049	0.437	0.010	10.930	9.819	0.066
Occupation						
Civil servant (ref)	0.000	-	-	0.000	-	-
Office worker	0.448	0.378	0.235	-0.589	8.488	0.945
Self employed	0.533	0.488	0.274	-15.429	10.941	0.158
Unemployed	0.448	0.421	0.287	-3.3981	9.454	0.719
Part time job	0.014	0.456	0.976	-19.590	10.243	0.056
Student	0.780	0.586	0.183	-16.436	13.168	0.212
Education						
High school or equivalent (ref)	0.000	-	-	0.000	-	-
University	0.146	0.012	0.041	-3.412	4.744	0.142
Others	0.617	0.344	0.073	-5.800	7.732	0.453
House ownership						
Owned house (ref)	0.000	-	-	0.000	-	-
Rent house	-0.039	0.242	0.872	2.459	5.425	0.650
Others	0.196	0.613	0.749	1.084	13.738	0.937
Gender						
Male (ref)	0.000	-	-	0.000	-	-
Female	0.008	0.216	0.115	3.276	4.858	0.500
Age	0.017	0.008	0.046	-0.126	0.186	0.047
No. of rooms	-0.075	0.073	0.306	1.140	1.639	0.039
Family size	-0.014	0.093	0.883	6.822	2.088	0.001

Significant at $^{***}p<0.01$ and $^{**}p<0.05$

Fig. 4.3 depicts a clear image of Japanese people's water consumption trends based on social, psychological, and behavioral aspects for a better understanding. People with a less positive attitude, limited awareness, minimal responsibility, fewer habits, negative feelings, and little involvement in any water conservation activities consumed more water than those who had not. Consequently, it can be inferred that these factors are quite significant in determining the quantity of water use and saving water.

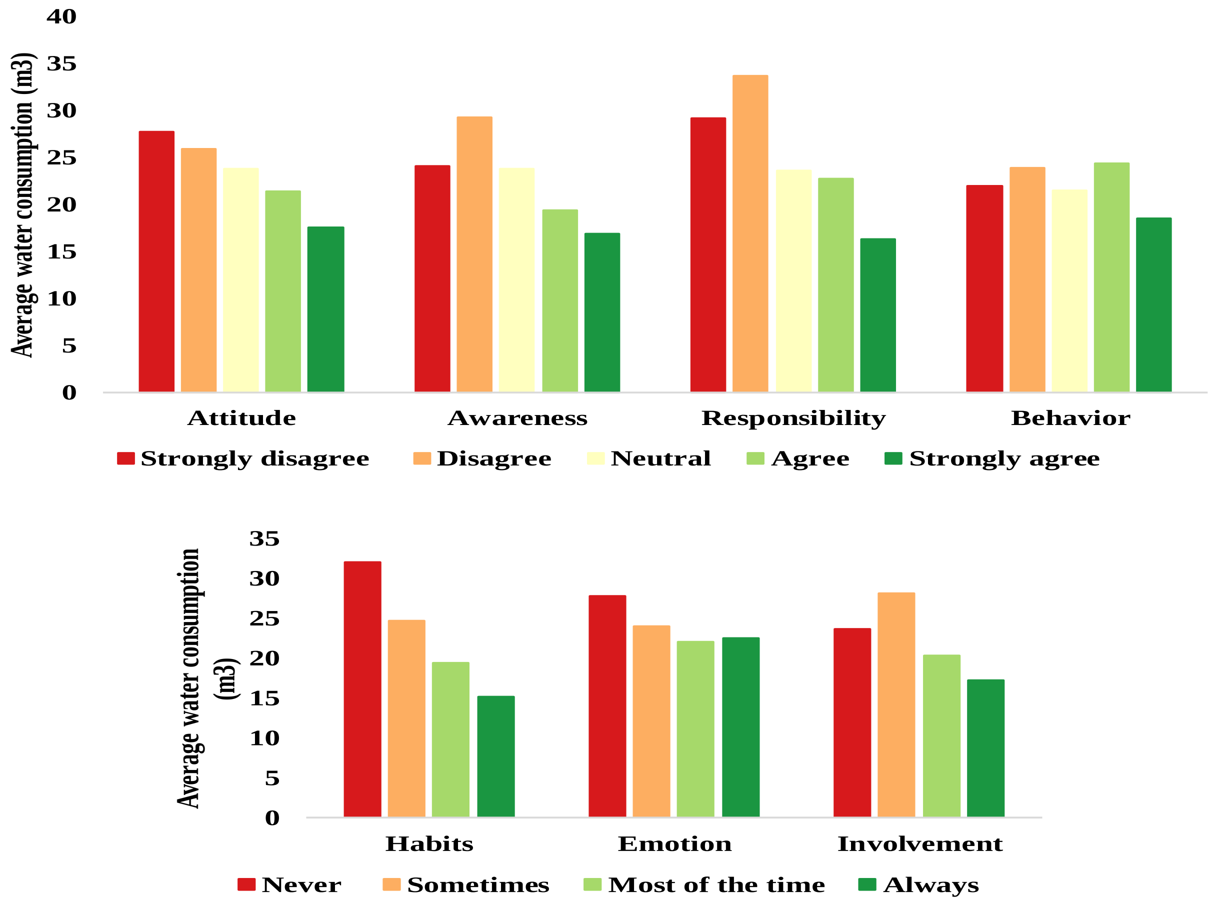

Fig. 4.3 Impact of socio-psychological and behavioral factors on water consumption based on highest loading items

4.3.4 Ordered logistic regression model

An ordered logistic regression analysis was carried out to confirm the robustness of the results. It is used when the dependent variable has a meaningful order, with more than two categories (or levels). This model is employed in the current study based on highest loading item from each construct. For instance, in case of attitude, we considered item 4 “I am highly passionate about water conservation” which loading was 0.72. The detailed results of the regression model are presented in Table 4.6.

Table 4.6: Ordered logistic regression for assessing the effect of socio-psychological and behavioral factors on the water conservation practice

Variable	Estimates	Std. Error	t-value	Odds ratio	p-value
Attitude					
Strongly disagree (ref)	0.0000	-	-	1.00	-
Disagree	0.0388	0.8688	-0.0447	1.04	0.964
Neutral	0.0258	0.8569	-0.0301	1.03	0.975
Agree	0.4765	0.8855	0.5381	1.61	0.590
Strongly agree	0.6173	1.0334	0.5973	1.85	0.057
Habit					
Never (ref)	0.0000	-	-	1.00	-
Sometimes	0.3002	0.3621	0.8289	1.35	0.407
Most of the time	0.6945	0.4427	3.8278	2.00	0.000
Always	1.1607	0.6610	4.7816	3.19	0.000
Awareness					
Strongly disagree (ref)	0.0000	-	-	1.00	-
Disagree	0.4257	0.7579	0.5616	1.53	0.5744
Neutral	0.4152	0.7383	0.5622	1.51	0.5741
Agree	0.8821	0.7643	1.1515	2.41	0.0495
Strongly agree	0.5875	0.9767	0.0896	1.80	0.0686
Emotion					
Never (ref)	0.0000	-	-	1.00	-
Sometimes	0.1849	0.3784	0.4885	1.20	0.6252
Most of the time	0.4937	0.4527	1.0906	1.63	0.0454
Always	0.3691	0.5233	0.323	1.44	0.1467
Responsibility					
Strongly disagree (ref)	0.0000	-	-	1.00	-
Disagree	0.4515	1.0595	0.4261	1.57	0.67
Neutral	0.3221	1.0083	-0.3195	1.38	0.7494
Agree	0.1338	1.0207	-0.1311	1.14	0.8957
Strongly agree	1.2342	1.1009	1.121	3.43	0.0623
Involvement					
Never (ref)	0.0000	-	-	1.00	-
Sometimes	0.4019	0.2539	1.5826	1.49	0.1135
Most of the time	0.2247	0.5571	-0.4034	1.25	0.0767
Always	0.2791	1.0158	-0.2746	1.32	0.1836
Income					
< 2 millions (ref)	0.0000	-	-	1.00	-
2-4 millions	-0.4108	0.3794	-1.0827	0.66	0.2789
4-8 millions	-0.3087	0.3838	-0.8042	0.73	0.4213
>= 8 millions	-0.1325	0.4481	-0.2959	0.87	0.0673

Table 4.6 continued

Occupation					
Civil servant (ref)	0.0000	-	-	1.00	-
Office worker	0.1927	0.4954	0.3889	1.21	0.6973
Self employed	0.8181	0.6174	1.3251	2.26	0.1851
Unemployed	0.0025	0.5245	-0.0044	1.01	0.9965
Part time job	0.1734	0.5733	0.3025	1.18	0.7623
Student	0.4809	0.6567	0.7324	1.61	0.4639
Education					
High school or equivalent (ref)	0.0000	-	-	1.00	-
University	0.4882	0.2567	-1.9016	1.63	0.0572
Others	0.5579	0.4121	-2.8099	1.75	0.1351
House ownership					
Owned house (ref)	0.0000	-	-	1.00	-
Rent house	-0.1634	0.3061	-0.5339	0.84	0.5934
Others	0.6061	0.7434	0.8153	1.83	0.4149
Gender					
Male (ref)	0.0000			1.00	
Female	0.4514	0.2722	1.6588	1.57	0.0972
No. of rooms	-0.1639	0.0905	0.7456	0.85	0.0559
Family size	-0.1633	0.1056	1.4012	0.83	0.0612
Age	0.0112	0.0096	1.1465	1.011	0.0516

Significant at $^{***}p<0.01$ and $^{**}p<0.05$ and $^{*}p<0.10$

The findings revealed that having a positive attitude, greater awareness, higher sense of responsibility, habit, emotion, and involvement toward water use increases the chance of an individual's water conservation behavior.

The outcomes by calculating the Odds ratio (OR) with confidence interval (CI) of socio-psychological and behavioral factors on water conservation behavior were presented in Fig. 4.4. Water conservation behavior was 1.85 times higher for those who strongly agreed with the water-saving attitude than others. Participants who reported having a greater awareness and responsibility about water issues involved water-saving activities 2.41 and 3.43 times higher than those who had not. Moreover, participants who stated greater habitual actions, emotions, and involvement in any conservation program were more likely to report practicing water conservation, which is 3.19, 1.44, and 1.32 times higher than others.

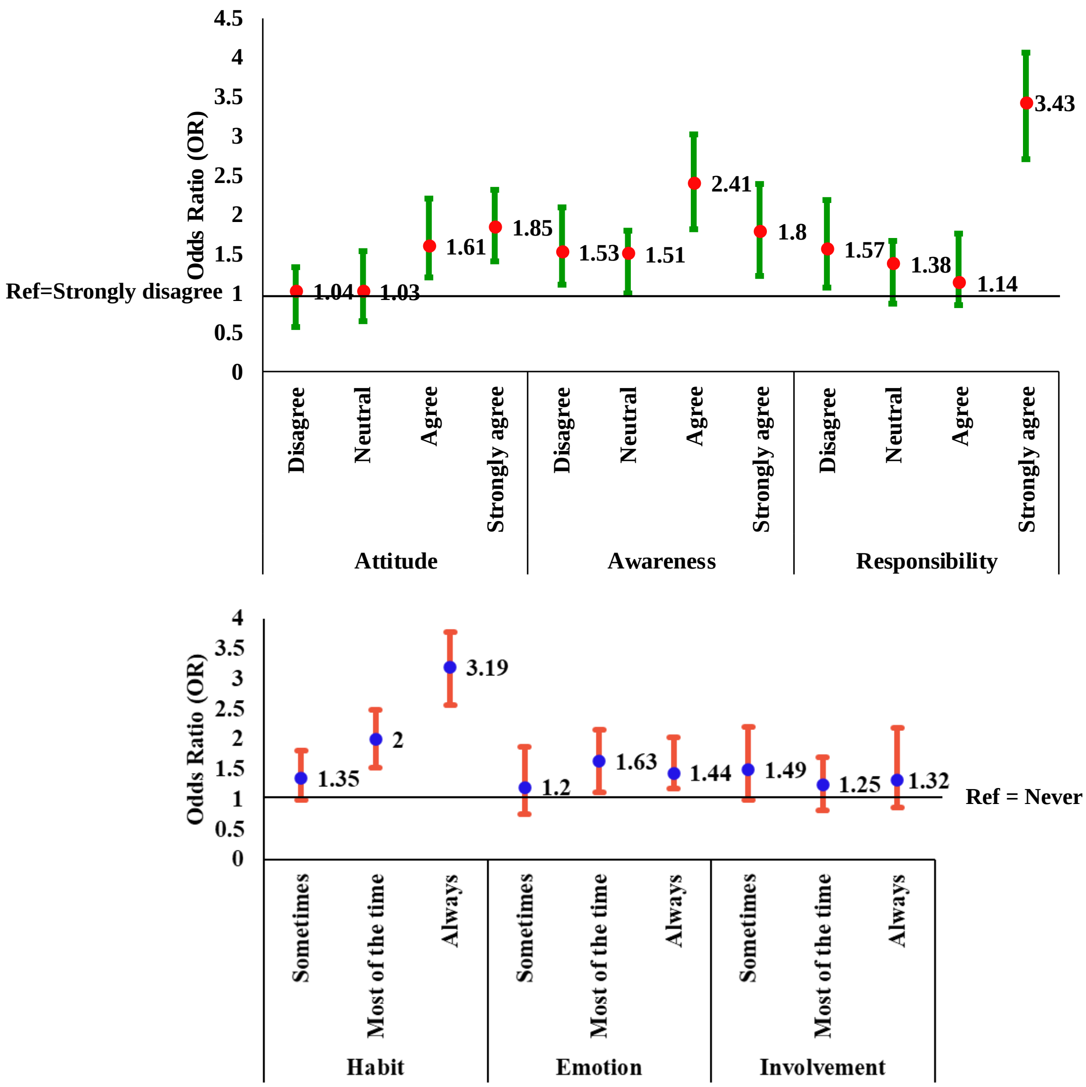

Fig. 4.4 Odds ratio (OR) with confidence interval (CI) of socio-psychological and behavioral factors on water conservation behavior

4.4 Discussion

Understanding the factors influencing household conservation behavior and consumption patterns is crucial for developing more effective behavioral approaches. Accordingly, the present research was the first effort to explain households' consumption and conservation actions based on the wide-ranging model combining the social, psychological, and behavioral determinants. The first step in a household adopting water conservation practices is understanding the significance of water conservation and knowing how to use less water. Thus, awareness of water conditions such as water demand and scarcity is critical for water-saving decisions. The current study found a substantial relationship among awareness, attitude, responsibility, involvement, and habits to water conservation, which is consistent with prior studies [33,35,61,71,172,173]. People are more willing to save water if they feel it to be a necessary and useful action. According to the findings of this study, people who have a positive outlook and strong moral responsibility to behave in an environmentally friendly manner demonstrate more favorable emotion toward conservation and engage in more conservation and less consumption actions. Emotions play a substantial influence in predicting all types of environmental involvement, according to existing research [65,80]. Furthermore, this study supported previous findings that emotion, water usage habits, and involvement all had a positive impact on water-saving activities [42,66,125,174] and negative impact on water consumption. The results demonstrated that only habit had a significant negative influence on consumption, but the influence of emotion and involvement was not significant. Households that conserved water had a culture of doing so; therefore, they used more water-saving habits or practices [6]. Habits [175,176,186] are performances that are repeated with little effort and directly influence conservation, particularly when people consider conservation a daily routine and seek ways to engage in more water conservation and fewer consumption activities on a frequent way. Furthermore, a user's level of involvement can influence his or her daily water usage activities. A consumer may be motivated to save water if he or she is involved in any educational or awareness program or training about the sustainability of water [134,138].

People in Japan are generally aware of how much water they use, and they have favorable attitudes and strong emotions toward conserving water, which makes them more responsible for their actions. They also have a strong habit and personal engagement to water-saving actions. The outcome of this study similarly revealed the same pattern of conclusions. However, apart from habit, the current study was unable to identify any significant association among emotion, involvement, and water consumption of Japanese households.

Finally, anticipating water usage behavior is revealed to be a complex operation that is driven by many pro-social and cognitive motives and is dependent on the stimulation of both personal (i.e. attitude, awareness, emotion, responsibility) and external elements (i.e. habit, involvement) [92,187,188].

4.5 Conclusion

To better understand which factors might be addressed in water demand reduction measures, the current study set out to identify the important variables of water use and conservation behavior. The structural equation model revealed a substantial relationship between awareness of water concerns and responsibility, attitude, habits, and involvement in the setting of water conservation practice. The results also revealed that these elements are highly related to how people felt about water use. Finally, it was observed that emotion, habit, and involvement are positively associated with conservation and negatively with water use. Families are more likely to adopt water conservation practices and use less water if they have stronger water-saving habits, strong emotions, and involvement in water-saving initiatives, campaigns, or training. The current model explained the variance in water-saving behaviors of 57 percent and the variance in water consumption behaviors of 55 percent. The analysis also indicated that respondents from higher income categories, young age groups, and when the number of rooms and family size increases, water conservation efforts deteriorate and water demand increases. The current study not just to provides in-depth understanding of the components that affect household water use and conservation but also gives various practical and conceptual implications to help policymakers better determine how to adopt more successful water security policies

Chapter 5

General Conclusion, Implications, and Future Plan

5.1 General conclusion

In addition to being an essential resource for agriculture, water is crucial for the social and economic development of many places. It is closely linked to the preservation of future human generations. Water issues have been named one of the top five global threats by the World Economic Forum. It is crucial to alter human behavior to conserve natural resources. To encourage water conservation, it is important to take into account the psychological, social, and behavioral variables that influence people's decision to adopt water-saving practices. Recent research has stressed the need to identify variables influencing behaviors that reduce water usage.

In order to better understand which elements might be targeted in campaigns to reduce water consumption, the current study set out to determine the significant factors that influence water-saving behavior. In the first project, the study carefully examined the effect of demographic, social, psychological, and behavioral variables as well as their interactions with an objective indicator of water conservation. The results of the structural equation model showed a strong correlation between knowledge of water issues, attitudes, responsibilities, and household culture to engage in water conservation efforts. People who worry about water shortages and their negative impacts on humankind, they are more responsible, have a better attitude, and have a higher level of a water conservation culture in their homes. The findings also showed that, with the exception of culture, these factors strongly influenced how people felt about water use. The culture variable is therefore not included in the study's next section (survey on Japanese people). Finally, it was shown that involvement, emotion, and habit all had positive and significant effects on behavior related to water conservation. Families who practice water conservation regularly, have a strong emotional bond, and take part in any indoor and outdoor water-saving activities or programs. The proposed model accounted for a 46% difference in water conservation practices among international employees and university students living in Fukuoka, Japan.

We won't be motivated to conserve water unless we are aware of future water problems. We can effectively conserve water and maintain this culture among our family members at home if we are all alert. Additionally, when we have a positive outlook, a sense of responsibility, and when we all cooperate to create the mindset to do so, we experience a great degree of emotion or inspiration to conserve water. This concept motivates people to participate in various conservation activities. Finally, by promoting a water-saving culture in our homes, we may develop a variety of water-use habits that eventually promote conservation.

Demographic variables (gender, age, and location) explained 13% of the variation in water-saving behavior in the sequential regression model. The inclusion of social variables significantly enhanced the percentage of variation explained (32%) in water conservation. The model's explanatory power increased noticeably to 48% when psychological components were considered. Last but not least, the model's capacity to explain 53% of the variation in conservation behavior was significantly improved by including habit as a behavioral feature. Interestingly, after the behavioral element (habit) was controlled for, participation and culture were found to be modest predictors, indicating that the influence of engagement and culture was mediated by habit.

In the second project, the goal of the study was to determine key elements influencing Japanese people's water consumption and conservation behavior. The structural equation model showed a strong correlation between responsibility, attitude, habits, and involvement in establishing water conservation practices and awareness of water concerns. Finally, involvement, emotion, and habit all had a positive correlation with conservation and a negative correlation with water use. Families with greater water-saving habits, strong emotions, and participation in water-saving initiatives or programs, campaigns, or training are more likely to adopt water conservation practices and use less water. The current model was able to account for 57% of the variation in water conservation behavior and 55% of the variation in water consumption behavior. The ordered logistic regression analysis showed that water conservation efforts decrease and water use rises among respondents from higher income categories, younger age groups, and when the number of rooms and family size increases. The current study offers detailed insights into the factors influencing household water usage and conservation and offers numerous practical and conceptual implications to aid decision-makers in developing more effective water security strategies.

5.2 Attributes and potential implications

Our key findings can be viewed as having immediate practical repercussions for influencing residential water users to adopt water-saving practices. This is the first research attempt to consider the multidimensional nature of water use behavior, including water conservation and consumption, contrary to the prevalent trend in the literature, which emphasizes the intention to conserve. Furthermore, limited research on water consumption had conducted in Japan; hence, this study adds new insight into the water use patterns of Japanese citizens. The focus of water-related research in Japan is on infrastructure development, wastewater reuse, and water purification. However, no solitary investigation on water uses and conservation was carried out to discover connected significant drivers to safeguard against upcoming water issues. Japan's infrastructure is quite advanced, but knowledge, responsibility, involvement, and healthy habits all play a big part in overcoming water difficulties. The broad awareness and responsibility of Japanese people—particularly elderly people—about environmental issues is well known. For young people to become more responsible, policymakers should use a variety of initiatives to get them involved in water conservation.

This study quantifies the direct and indirect effects of social, psychological, and behavioral effects on water conservation practice and water consumption. Additionally, based on the results of the study, the conceptual perspective described in this paper has a higher predictive capacity, indicating that the current model is an efficient and useful tool in the field of water conservation and consumption behavior research. The present study also includes demographic and situational factors as control variables in the main analysis.Even though demographic characteristics are significant in determining individual water use behavior, most studies in this field did not include them in respective analyses.

The results underline how important behavioral, psychological, and social elements are in shaping people's attitudes about water conservation. As a result, while developing any policies or initiatives for water conservation, these challenges must be taken into account. Policies that seek broader social support and establish circumstances that motivate households to adopt water conservation are necessary for the implementation of water conservation plans and initiatives [21,63,189]. Our major findings have practical implications for policymakers and authorities who want to encourage people to save water and achieve the objective of sustainability. Any initiatives and programs require policies aiming for a wider level of public acceptance and to develop situations that support household attitudes, emotions, habits, and involvement in water-saving practices, as well as a large-scale social shift toward an environmentally responsible lifestyle [109,189]. To ensure long-term behavior change, the applied strategies should also aim to transform habitual action into a deliberate activity [49,72,76]. Public policies that introduce diverse educational campaigns or training programs and promote citizen participation in these activities are favorably associated with water conservation behavior. On the other hand, policymakers can encourage water conservation by raising public knowledge of environmental issues. Promoting environmental awareness on the preservation of natural resources through television or other social media might have a favorable effect on water conservation behavior, directly or indirectly, by connecting environmental issues with water conservation. Individuals are accountable for preserving the natural environment, and conservation behavior is socially valued, so using different forms of social media to enhance awareness about the sustainable use of resources can initiate the formation of positive attitudes, responsibility and thus increase behavioral intention levels. Lastly, given the paucity of research in this field, academics need to focus on issues like emotion, involvement, and responsibility in addition to policies.

5.3 Limitations

This study has some limitations, although a detailed analysis was done to fill in the gaps in the available literature. Six hundreds twenty five (625) overseas students and workers and Five hundreds fourteen (514) Japanese respondents from Fukuoka Prefecture, Japan, participated in the current study. It was quite challenging for us to obtain the data outside of Fukuoka Prefecture because to COVID 19. Future research should look at the results' generalization and see whether the proposed model can be used in other regions or not. Another limitation is the data of the present study was collected in COVID-19 pandemic that resulted in an increase of domestic water consumption and decrease conservation activities in the study area. Participants used more water to wash their hands, took more showers, washed clothes, and the entire floor of their homes during COVID than before. Future research should take this situation into account. Future research should include additional variables to expand the current research and improve the variance. Furthermore, a range of additional psychological factors (i.e motivation, norms, values, connectedness to nature) and contextual considerations such as resources, time pressure, pricing, and infrastructure were not included in the current study that have been found to influence the conduct of environmentally beneficial activities [50,73,92,190]. Additionally, because the current study was cross-sectional in nature, the findings may vary in different time periods, target populations, or study settings. Researchers ought to consider these cases as the next step in enhancing these qualities. Upcoming research should explore these challenges and include contextual aspects as well as additional psychological determinants of behavior in relation to participants' socio-economic and demographic outlines. Finally, future research should combine all the study factors examined in this study with commonly used variables in various theories, such as the theory of planned behavior and the value-belief-norm theory.

5.4 Future work

In the literature on environmental science and water science, there are a number of theories have been proposed. Numerous scholars expanded on these theories by combining new variables with preexisting ones. I intend to combine the variables from my current study with some of the most popular theories, including the theory of planned behavior and the value-belief-norm theory in the future.

In several urban areas of Bangladesh, water shortages are a typical occurrence. Despite the numerous rivers surrounding this country, most of the water is polluted. Drought, arsenic, and unsafe drinking water are all rather prevalent. Additionally, the general public shows no sign of concern for these water problems, which could become serious in the near future and seriously harm the next generation. Additionally, because water meters are not available to every household, the government is unable to accurately monitor the level of water use. Since every household has a set water bill, the majority of people are unaware of how much water they actually use on a daily basis.

Public awareness, positive attitudes, negative emotions toward water wastage, social responsibility, public involvement, government policy and infrastructure development are also required to safeguard the water situation. Utilizing this perspective as a guide, I propose to conduct a study on Bangladeshi people in the future using a current questionnaire to find out how much the general public is aware of water issues, how they feel about saving water, and how involved and culturally committed they are.

Water challenges have become a major source of concern on a global scale due to the increased demand for water and the resulting strain on freshwater resources. As a practical solution to the rising water demand and limited freshwater supply, water conservation, desalination of sea water, and reuse of treated wastewater are widely investigated and acknowledged as being effective.

Wastewater that comes from industrial, commercial, or agricultural operations that has been treated to a level that is suitable for reuse is referred to as treated wastewater. The use of treated wastewater is expanding, not just as a substitute for freshwater but also as a tool to slow down environmental deterioration. Reusing wastewater is an important tactic for protecting limited water supplies. Recent advancements in wastewater reuse technology imply that highly treated wastewater may play a significant role in environmentally sound water security solutions.

Although the usage of recycled water is logical, some are nevertheless hesitant to do so. Individual water reuse behavior is influenced by a variety of factors, including attitude, awareness, negative emotion, trust, cost, environmental and health risk and more. As a part of my future research, I would like to construct a questionnaire on how the general public feels about and accepts treated wastewater, emphasizing on numerous factors.

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Appendices

Survey Questionnaire in English

Basic Information (Demographic Variables)

What is your age range?

- 18-24
- 25-31
- 32-38
- 39-45
- 46-52
- 53-59
- Above 60

What is your Gender?

- Male
- Female
- Others

Your Education:

- Less than high school degree
- High school degree or equivalent
- Bachelor's degree
- Graduate degree

Your occupation:

- Student
- Government job
- Private job
- Others (Retired or unemployed)

Your current living status:

- Dormitory
- Rented House
- Own House

Types of houses:

- Detached house
- Apartment

Number of rooms:

Number of your Family members:

Your annual income level (Tax included):

- Less than 2 million yen
- 2-4 million yen
- 4-6 million yen
- 6-8 million yen
- 8-10 million yen
- 10-15 million yen
- 15-20 million yen
- 20 million to more

Your average water bill (Monthly):

Constructs and measurement items (Psychological, social and Behavioral Variables)

Constructs	Number of items	Items
Attitude	6	There is a lot of vital reasons for saving water to become valuable. Everyone should use less water as they can. I am very positive about water-saving. Water shortage issues always make me upset. Saving water is more important than my comfort. I think saving water is time-consuming and takes more effort. (Reverse scoring)
Awareness	8	I am concerned about the availability of water in the future. I am conscious of the amount of water use in each day. All residents should be encouraged to conserve water. I am concern about the impacts of the water crisis on human life. I think there is a need to conserve water worldwide. I try to learn effective ways to save more water. Awareness about water conservation should start from schools and home. It is not essential to be alert about the use of water. (Reverse scoring)
Responsibility	6	Being responsible citizens, we must conserve water. We should save water for the next generation/future. It is our concern to build up the culture of conserve water in every younger household. I don’t mind convincing others to conserve water. We should monitor the water meter frequently.

		Water conservation is not only my responsibility. (Reverse scoring)
Habit	7	I usually take a shorter shower. I usually turn off the water while brushing teeth, soap-up, and shaving. I normally don’t let the faucet run while cleaning vegetables and rinsing dishes. I usually use the bucket to wash the car and water garden plants. I use half flash or do not flash every time. I use minimal water in the kitchen. I use the washing machine only for full loads.
Emotion	7	I feel good when I can save water. Someone who is trying to save water, it makes me happy. When I see the water is wasted from a running tap or toilet, I feel upset. I Feel disturbed when water is wasted in public places (for example water leak in the street). I Feel sad when I see someone use excessive water in their everyday life. When I see the lack of awareness of some people regarding water conservation, I feel sad. I feel guilty or sad when I waste water or someone else does.
Household culture	5	My household members think that water conservation is a good thing. My household members usually engage to save water. My household members usually take a shorter shower. Comfort is more important to my family members than save water. (Reverse scoring)

		My family members are independent to use water. (Reverse scoring)
Personal Involvement	5	I usually participate in any awareness or educational program regarding environmental issues. I discuss it with my friends and family about water issues frequently. The decision concerning water use at home is up to me. It is valuable to me involving any water-saving program. Lack of motivation affects my involvement to conserve water. (Reverse scoring)
Conservation behavior	5	I conserve water whenever and wherever I can. I use water-saving appliances at home. I check toilets, faucets, and pipes for leaks and fix them immediately. I use just as much water as I need. I am not concerned about water conservation. (Reverse scoring)
Statement on Water cost	1	Water cost influences the amount of water use and water saving behavior.
Multiple choice question	1	Which factor is more dominant in water saving to you? 1. Awareness about water issues 2. Motivation to save water 3. Positive Attitude 4. Household Culture 5. Water Price

Survey Questionnaire in Japanese Language

属性

年齢

- 18 - 24 歳
- 25 - 31 歳
- 32 - 38 歳
- 39 - 45 歳
- 46 - 52 歳
- 53 - 59 歳
- 60 歳以上

性別

- 男性
- 女性
- 上記以外

最終学歴:

- 中学校
- 高等学校 またはそれに準ずるもの
- 大学
- 大学院

職業:

- 学生
- 公務員
- 会社員 / 自営業

- 上記以外 （定年退職者または無職）

現在の住居形態:

- 寮
- 借家
- 持ち家

住居の種類:

- 一戸建て
- 集合住宅

部屋数:

家族の人数:

年収 （税込）:

- 200 万円未満
- 200 万円以上 - 400 万円未満
- 400 万円以上 - 600 万円未満
- 600 万円以上 - 800 万円未満
- 800 万円以上 - 1,000 万円未満
- 1,000 万円以上 - 1,500 万円未満
- 1,500 万円以上 - 2,000 万円未満
- 2,000 万円以上

水道料金 （月平均）:

Constructs	Number of items	Items
節水行動	5	常に節水を心掛けている
		自宅に節水機器を設置している
		トイレ、水道の蛇口及び給水管を確認し、水漏れに気付いた場合は直ちに修理をする
		節水には関心がない
		必要以上に水を使っている
節水に対する考え	6	節水の有用性を示すもっともな根拠が数多くある
		誰もが出来る限り水の使用を減らすべきだ
		節水の取り組みに対して大変肯定的である
		水不足の問題を常に危惧している
		快適な生活を犠牲にしてまでやる程の事ではない
		節水は手間がかかるし面倒だ
		シャワーは短時間で済ませるようにしている
		歯磨き、石鹸での洗浄、髭剃り中に水を出しっぱなしにしないようにしている
		蛇口から水を出しながら野菜を洗ったり、洗った皿をすすいだりしないようにしている

節水の習慣	7	洗車や庭の水やりにバケツを使っている
		トイレの使用後「小」レバーで水を流す、あるいは毎回は流さない
		台所での水の使用を最小限に抑えている
		洗濯物はまとめ洗いをしている
		将来における利用可能な水量の減少を懸念している
		毎日使う水の量に気を付けている
水に関する意識	7	全ての住人に節水を促すべきだ
		水危機が人命に与える影響について関心を持っている
		世界全体で節水を進める必要があると考えている
		効果的な節水方法に関する情報収集を積極的に行っている
		水の使用について特段意識する必要はない
		節水が出来ていると思うと気分がいい
		節水への取り組みを見聞きすると嬉しくなる
		水道の蛇口やトイレの水が出しっぱなしになっているのを見ると嫌な気分になる

水の使用に対する感じ方	7	公共の場で水が無駄になっているのを見ると気になってしまう（例えば公道での漏水等）
		水を日常的に無駄使いしている人を見ると嘆かわしく思う
		節水意識に欠ける人を残念に思う
		水の無駄使いに対する罪の意識はなく、そういう人を見ても不快に感じない
		私の同居家族は節水は良い習慣であると考えている
節水に対する義務感	5	節水は市民としての義務である
		次世代や未来世代の為に節水をするべきだ
		若年世帯に節水の習慣を植え付ける事は重要な課題である
		節水は自分一人の努力だけではどうにもならない
		水道メーターを頻繁に確認することが必要だ
		環境問題に関する意識喚起や教育活動に参加している
		家族や友人と頻繁に水問題に関する話しをする

自身の関わり	5	家庭での水の使用については私に決定権がある
		動機付けがないと節水に取り組もうという気になれない
		節水の取り組みに関わることは無意味である
水道料金	1	水道料金は水の使用量や節水行動に影響を及ぼす

❖ あなたの水の使用や節水行動の決め手となっているのは?

1.（節水に対する）肯定的な態度
2. 水問題に対する意識
3. 節水への動機付け
4. 家庭での習慣
5. 水道料金

毎月どのくらいの水道料金を払っていますか？

List of Publications

Journal Publications

- “Quantifying the Direct and Indirect Effect of Socio-psychological and Behavioral Factors on Residential Water Conservation and Consumption in Japan’’, **Bipasha Singha**, Shamal Chandra Karmaker and Osama Eljamal, *Resources, Conservation & Recycling*, Volume-190, March 2023, 106816.

- “Water Conservation Behavior: Exploring the Role of Social, Psychological, and Behavioral Determinants’’, **Bipasha Singha**, Osama Eljamal, Shamal Chandra Karmaker, Ibrahim Maamoun and Yuji Sugihara, *Journal of Environmental Management*, Volume-317, September 2022, 115484.

- “Changing Patterns of Household Water Consumption and Conservation Behavior in Bangladesh: An Exploration in the Context of COVID-19 Pandemic”, **Bipasha Singha**, Shamal Chandra Karmaker and Osama Eljamal, *International Journal of Innovation and Sustainable Development* (Accepted).

Conference Proceedings

- “Evaluating the Social and Psychological Factors about the Public Acceptance of Treated Wastewater Reuse: A Review’’, **Bipasha Singha** and Osama Eljamal, Proceedings of 8th International Exchange and Innovation Conference on Engineering & Sciences (IEICES), Fukuoka (Japan), pp. 259-263, October 2022.

- “Growing Awareness and Positive Attitudes toward Water Saving to promote Water Conservation Practices’’, **Bipasha Singha** and Osama Eljamal, Sustainability and Development Initiative Conference 2022, University of Michigan, USA , January 2022.

- “Exploring Attitude and Household Culture to Encourage Water Conservation Behavior’’, **Bipasha Singha** and Osama Eljamal, Proceedings of 7th International Exchange and Innovation Conference on Engineering & Sciences (IEICES), Fukuoka (Japan), pp. 149-154, October 2021.

- “A Review on Water Conservation and Consumption Behavior: Leading issues, Promoting actions, and Managing the policies’’, **Bipasha Singha** and Osama Eljamal, Proceedings of 6th International Exchange and Innovation Conference on Engineering & Sciences (IEICES), Fukuoka (Japan), pp.171-178, October 2020.