THE INFLUENCE OF THE SELF-TRANSCENDENT VALUE ORIENTATION ON PRO-ENVIRONMENTAL BEHAVIORAL INTENTION TOWARD WASTE-TO-VALUE FOOD: EVIDENCE FROM VIETNAM

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Abstract - Waste-to-Value Food has gained increasing attention in both practice and academic research due to its contribution to environmental conservation. This study aims to examine consumers' Pro-environmental Behavioral Intention toward Waste-to-Value Food by exploring the influence of Self-transcendent Value orientation, particularly Biospheric and Altruistic Values within the Value-Belief-Norm Theory. A quantitative approach was employed using structural equation modeling (SPSS and PLS-SEM) to analyze data collected from 309 Vietnamese respondents. The findings reveal that Pro-environmental Behavioral Intention is influenced by Biospheric Value, Altruistic Value through a sequential mediating chain of Belief and Personal Norm. This study offers deeper insight into the social and psychological mechanisms underlying consumers' Pro-environmental Behavioral Intention toward Waste-to-Value Food.

Key words - Waste-to-Value Food; Value-Belief-Norm theory; Self-transcendent Value orientation; Pro-environmental Behavioral Intention; Biospheric Value; Altruistic Value

1. Introduction

"What if food waste could not merely be an urgent problem to be reduced, but a resource to be revalued?"

Food waste is no longer simply a matter of inefficiency, but has become a pressing and socio-economic challenge. Across global food systems, discarded food contributes considerably to resource depletion, greenhouse gas emissions, and escalating waste management burdens [1], [2]. In light of this situation, the circular economy advocates retaining materials and products' value over the longest possible life cycle, including transforming food waste into value-added outputs [3]. Within this context, Waste-to-Value (WTV) Food has emerged as an innovative solution that converts food surplus and by-products into new food products with enhanced functional or nutritional value [4], [5].

Despite its environmental and technological feasibility, the diffusion of WTV Food ultimately depends on consumer acceptance. However, prior studies have emphasized technological processes, policy frameworks, or supply-chain management [6], [7], while the psychological and moral drivers underlying consumers' Pro-environmental Behavioral Intention in this specific context have been limited.

The Value-Belief-Norm (VBN) theory provides a robust framework for understanding how individuals' intrinsic values activate personal norm that guide Pro-environmental Behavioral Intention [8]. Within this framework, Self-transcendent Value orientation, particularly Biospheric and Altruistic Values - represent moral orientations that prioritize environmental protection and the welfare of others [9]. Although, these value orientations are considered to be central in motivating environmentally responsible behaviors. However, empirical investigations isolating the role of Self-transcendent Value orientation in shaping Pro-environmental Behavioral Intention toward WTV Food remain limited, especially in emerging markets.

Vietnam represents a suitable research context. The country is experiencing increasing pressure from food waste and environmental degradation, while awareness about sustainable consumption is rapidly increasing [10], [70], [71]. Nevertheless, WTV Food remains relatively unfamiliar to many consumers, and the value-moral norm mechanisms fostering their Pro-environmental Behavioral Intention have not yet fully been understood.

Therefore, this study empirically tests a VBN model focusing on Self-transcendent Value orientation to explain Pro-environmental Behavioral Intention toward WTV Food in Vietnam. Specifically, it examines how Biospheric and Altruistic Values influence Ecological Worldview and personal norm, which in turn shape Pro-environmental Behavioral Intention; moreover, this study also evaluates the impacts of Biospheric and Altruistic Values on personal norm and thereby Pro-environmental Behavioral Intention. By focusing on the Self-transcendent Value orientation, this research contributes to refining the value mechanisms driving the sustainable food innovation adoption in emerging economies.

2. Literature review

2.1. Concept of Waste-to-Value Food

In existing studies, WTV Food is frequently discussed under various terms, including upcycled food, value-added-surplus products, or side-stream valorisation [11], [12], [13]. Regardless of these specific terminologies, the core concept focuses on transforming food not intended for human consumption into eco-friendly products via transparent supply chains, and that has a positive impact on the environment [14]. Moreover, these prior studies have clarified this concept by establishing three defining characteristics as follows: 1) it incorporates potential waste materials; 2) these materials are processed into edible food for humans; 3) it generates additional values [15]. Ultimately, these attributes position WTV Food as a cornerstone of circular food systems, offering substantial promise for driving sustainable transitions across the global agriculture and food sectors [16].

2.2. The Value-Belief-Norm theory

In recent decades, theories in social psychology have provided an important foundation for explaining pro-environmental behavior - intentional actions aimed at minimizing an individual's negative impact on the environment [8], [17]. Among these, the Value-Belief-Norm (VBN) theory [8] is a foundation framework developed from the Norm Activation Model (NAM) [18], [19]. VBN theory also extends NAM by integrating intrinsic values and the Ecological Worldview which was measured using New Ecological Paradigm (NEP) scale [20], thereby emphasizing how personal norm and moral responsibility translate values into Pro-environmental Behavioral Intention. The theory has been widely applied across contexts such as sustainable consumption, energy conservation, and environmental protection [17], [21]. Conceptually, The VBN theory explains pro-environmental behavior through a sequential chain of three core constructs: Values - Beliefs - Norms.

2.2.1. Values

Within the VBN framework, values are considered the most essential antecedents, specifically Self-transcendent Value orientation. Self-transcendent Value orientation, including Biospheric Value and Altruistic Value, influence environmental beliefs following the causal sequence proposed by VBN theory.

Firstly, Biospheric Value highlights concern for ecosystem integrity and non-human species, reflecting individuals’ fundamental belief that nature holds inherent value and should be protected [22], [23]. These values also include the belief in maintaining environmental quality for the long-term benefit of humankind [24]. Secondly, Altruistic Value refers to a set of beliefs that emphasize a strong concern for the welfare of other people [25], [8].

These two values serve as the motivational foundation upon which environmental beliefs are developed within the VBN chain.

2.2.2. Beliefs

Building upon value orientations, VBN theory proposes that environmental beliefs function as the cognitive connection between values and norms. Environmental beliefs are primarily expressed through an extension of NEP theory - the Ecological Worldview.

Ecological Worldview refers to individuals’ general, context-independent beliefs regarding the relationship between humans and the natural environment. It is commonly measured using the NEP scale and represents overall environmental beliefs rather than assessments of specific behaviors [20].

Through this belief system, abstract values are translated into moral considerations that lay the groundwork for personal norm [22].

2.2.3. Norms

Within the VBN framework, personal norm is viewed as the closest predictor of pro-environmental behavior. Onwezen’s study defines personal norm as “individual moral convictions which might be used as personal standards to evaluate behavior” [21]. In a similar vein, Han et al. describe a personal norm which is activated through a sequential cognitive process that involves Ecological Worldview [26]. Once this moral obligation is triggered, it functions as the direct psychological motivator of pro-environmental intentions.

3. Hypothesis development

3.1. Biospheric Value and Ecological Worldview

Grounded in the NEP theory, ecological belief systems reflect individuals’ awareness of biospheric vulnerability and human-induced environmental degradation [20], [27]. Within the VBN framework, Biospheric Value activates cognitive appraisal by providing a moral lens through which individuals interpret environmental stimuli as threats requiring collective action [8]. Prior empirical evidence has consistently validated the role of environmental values in strengthening ecological belief structures across different contexts [28], [29]. Extending this logic to the WTV Food context, individuals who strongly endorse Biospheric Value are more likely to interpret food waste through a sustainability-oriented lens, recognizing its environmental implications and circular potential. Therefore, Biospheric Value is expected to positively influence Ecological Worldview in this domain. Thus, the following hypothesis was formulated:

H1: Biospheric Value has a significant impact on Ecological Worldview.

3.2. Altruistic Value and Ecological Worldview

Altruistic Value operates through social interdependence mechanisms, where concern for others' welfare extends to future generations and ecosystems. Similarly, studies have shown that Altruistic Value is positively associated with Ecological Worldview [8], [30]. At the same time, previous studies in the environmental behavior literature indicate that people who have a strong Self-transcendent Value orientation develop more profound environmental beliefs and participate more vigorously in actions that are environmentally responsible compared to those with a weak Self-transcendent Value orientation [8], [25], [31], [23]. As WTV Food products are perceived as contributing to environmental protection and social well-being, individuals with stronger Altruistic Value are more likely to hold Ecological Worldview that support such sustainable food consumption. Thus, the study puts forth the following hypotheses:

H2: Altruistic Value has a significant impact on Ecological Worldview.

3.3. Biospheric Value and Sense of Obligation to Take Pro-environmental Actions

Personal norm plays a crucial role in connecting values with environmentally friendly behavior. Schwartz [18], Stern et al. [22] developed a VBN theory suggesting that biosphere value orientation is positively related to the formation of a personal norm for behaving in a sustainable way. Furthermore, previous studies have shown that Biospheric Value directly and indirectly influences human environmental behavior through personal norm [32], [33]. Therefore, Biospheric Value reinforces personal norm as a key mediator driving consumers' intention to adopt WTV Food. Hence, this study formulates the following hypothesis:

H3: Biospheric Value has a significant impact on Sense of Obligation to Take Pro-environmental Actions

3.4. Altruistic Value and Sense of Obligation to Take Pro-environmental Actions

Likewise, Stern established Altruistic Value as direct antecedents of personal norm through moralization of pro-social environmental acts benefiting others [8]. Empirical evidence further indicates that unlike Biospheric Value targeting nature directly, Altruistic Value activates via perceived harm to human communities from environmental degradation [34], [33]. As WTV Food consumption reduces food insecurity while protecting the environment, individuals with stronger Altruistic Value are more likely to internalize a moral obligation to support such sustainable food initiatives. Hence, this paper submits the following hypothesis:

H4: Altruistic Value has a significant impact on Sense of Obligation to Take Pro-environmental Actions

3.5. Ecological Worldview and Sense of Obligation to Take Pro-environmental Actions

Personal norm stems from individuals' internalized values and belief systems that shape their sense of moral responsibility [35]. Within the Norm Activation Model, Ecological Worldview provides cognitive foundation for norm activation by establishing adverse consequences and ascription of responsibility [18]. Besides, Ecological Worldview functions as a direct cognitive basis for activating moral obligation. Prior studies consistently confirm the significant influence of environmental beliefs (including Ecological Worldview) on personal norm in other settings [26], [36], [37], [38]. In the context of WTV Food, individuals with a stronger Ecological Worldview may activate consumers' sense of obligation to support sustainable food alternatives, as hypothesized below:

H5: Ecological Worldview has a significant impact on Sense of Obligation to Take Pro-environmental Actions

3.6. Sense of Obligation to Take Pro-environmental Actions and Pro-environmental Behavioral Intention

Recent research conceptualizes personal norm as internalized moral expectations that guide individuals toward environmentally friendly behaviors, finally shaping their intentions to engage in pro-environmental actions [39], [40]. Accordingly, individuals rely on their personal norm to determine whether to engage in behaviors that help prevent negative environmental outcomes [41]. Within food choice settings, stronger personal norm has been shown to positively influence consumers' intentions to adopt sustainable food practices and reduce food waste [42], [43]. Based on the above discussion, this study proposes the following hypothesis:

H6: Sense of Obligation to Take Pro-environmental Actions has a significant impact on Pro-environmental Behavioral Intention

4. Research methodology

4.1. Research methods

This study employs a quantitative approach using questionnaire-based surveys to validate measurement scales and test the research model within the WTV Food context. By analyzing primary data from a large consumer sample, the research provides empirical evidence on key variable relationships and offers insights into consumer perception and behavioural intentions in this limited domain.

4.2. Sampling techniques

The method of choice is non-probability sampling. For further details, convenience sampling is the sampling strategy employed, which is consistent with the intentional approach in the pre-test and official survey's first phase [44]. Besides, the sample size is not based on sampling error because convenience sampling is used.

4.3. Data collection

The study used primary data collected through a questionnaire survey, distributed both online via Google Forms and offline in paper format. Participants were recruited through social media and in-person distribution, with small non-profit incentives offered as appreciation.

Figure 1. *Illustrative examples of WTV Food*

A structured questionnaire was used as the main instrument. Participants were informed about the research objectives and assured of anonymity before completing the survey. As the study examined factors influencing consumers' Pro-environmental Behavioral Intention toward WTV Food, no screening criteria were imposed during the sampling process. The survey, therefore, targeted general consumers rather than limiting respondents to individuals who already demonstrate interest in sustainable consumption or environmental protection. This approach allows the study to capture a broader range of consumers, including those who may not yet actively engage in pro-environmental consumption behaviors but may still develop such intentions.

To enhance the validity of responses, the survey was designed so that participants received an explanation of WTV Food before proceeding to the main questionnaire: Waste-to-Value Food refers to food products that transform waste or surplus materials generated during the production of other food products into new value-added food products with higher nutritional value. This type of food applies a circular approach to enhance nutritional value or extend the shelf life of food. Several visual examples of value-regenerated food were also provided:

To ensure response quality, a filter question was included as an attention check during the questionnaire. Specifically, respondents were asked "How do you feel?" and instructed to select "Rain" as the predetermined answer. Respondents who selected an incorrect answer were excluded from the final dataset. By providing a definition, visual examples, and an attention-check question, the study sought to ensure that participants were able to provide meaningful and valid answers within the specific context of WTV Food.

4.4. Measurements

This study utilized established measurement scales, modifying them to suit the specific context of WTV Food. Self-transcendent Value orientation (4 items of Biospheric Value (BV) and 4 items of Altruistic Value (AV)) were adopted from Han et al. [45] and Steg et al. [46]. Measurement of Ecological Worldview (EW) relied on 3 validated items from several scholars. Specifically, EW1 ("The balance of nature is very delicate and easily upset" was adapted from Cordano et al., while EW2 ("The earth is like a spaceship with limited room and resources") and EW3 ("Humans are severely abusing the environment") were adapted from Stern et al. [22], [47]. Additionally, Sense of Obligation to Take Pro-environmental Actions (SOTPA) (4 items) and Pro-environmental Behavioral Intention (BI) (4 items) were derived from Han et al. [45] and Wynveen et al. [48]. All variables were assessed using a uniform 5-point Likert scale to ensure consistency and secure the reliability of the measurement model.

Gender, age, education level, and income were included as control variables to account for potential demographic influences on the dependent variable.

5. Results and Discussion

5.1. Sample Profile

A total of 371 questionnaires were initially collected. After removal of incomplete or invalid responses, 309 valid responses from Vietnamese participants were retained for analysis. In terms of gender, females accounted for 58.6% (n = 181), while males represented 41.4% (n = 128). The age distribution was concentrated in younger groups: 13.9% were under 18, 46.9% were 18-24, 26.5% were 25-34, 9.4% were 35-44, 1.9% were 45-54, and 1.3% were above 55. Regarding education, 10.7% had secondary/high-school education, 80.9% held a college/university degree, and 8.4% had postgraduate qualifications. For monthly income, 20.7% earned under 1 million VND, 42.7% earned 1-5 million VND, 18.8% earned 5-10 million VND, 11.0% earned 10-20 million VND, and 6.8% earned above 20 million VND. Overall, the sample is dominated by young, female, and university-educated respondents with mostly low-to-mid monthly income, which may influence the observed attitudes and Pro-environmental Behavioral Intention in the model.

5.2. Descriptive statistics of variables

The descriptive statistics of core constructs, including Mean and Standard Deviation, were evaluated on a 5-point Likert scale. To be specific, Self-transcendent Value orientation recorded the highest average scores. AV ranked first (Mean = 4.19, SD = 0.86), closely followed by BV (Mean = 4.15, SD = 0.85), and EW (Mean = 4.14, SD = 0.79), respectively. Meanwhile, SOTPA (Mean = 3.77, SD = 0.81) and BI (Mean = 3.76, SD = 0.79) exhibited relatively lower and standard deviation scores.

Table 1. *Descriptive statistics*

Constructs	Mean	S.D.	Range of data
BV	4.15	0.85	1-5
AV	4.19	0.86	1-5
EW	4.14	0.79	1-5
SOTPA	3.77	0.81	1-5
BI	3.76	0.79	1-5

5.3. Exploratory factor analysis

EFA was conducted in SPSS 20.0 using Principal Component Analysis to explore the latent structure and inter-item relationships [55]. The data were suitable for factor analysis, with a strong KMO value (0.899) and a significant Bartlett's test (χ^2 = 2816.361, df = 171, p = 0.000) [56].

With N = 309, a loading threshold of 0.40 was applied [57]. The final solution retained 19 out of 19 items with acceptable communalities (0.518-0.732), with no item eliminated during the analysis because all items satisfied the retention criteria, indicating good representation by the extracted factors. The results show that BV4, EW2, and BI4 had the highest extraction values, with communalities of 0.732, 0.694, and 0.684, respectively, indicating that these three items were the strongest represented items in the factor structure.

5.4. Measurement Validity and Construct Reliability

The evaluation of the measurement model focused on indicator reliability, internal consistency, convergent validity, and discriminant validity. First, indicator reliability was established, with all standardised external loading coefficients exceeding the 0.7 threshold [49]. Subsequently, internal consistency was confirmed as Composite Reliability (CR) values surpassed the 0.70 minimum recommended by Hair et al. [50]. While the EW construct yielded a Cronbach's Alpha of 0.685, this is deemed acceptable in exploratory contexts [51], [50], especially given its strong CR of 0.826. Convergent validity was confirmed by AVE scores ranging from 0.610 to 1.000, all of the latent variables exceeded the 0.50 standard [52].

Table 3. *Construct reliability and validity*

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
AV	0.844	0.849	0.895	0.682
BV	0.869	0.877	0.910	0.717
EW	0.685	0.686	0.826	0.614
SOTPA	0.786	0.788	0.862	0.610
BI	0.833	0.838	0,888	0,666

Finally, discriminant validity was verified using both the Fornell-Larcker criterion and the cross-loadings matrix [52]. As shown in Table 4, the square root of the AVE for each construct (lower triangular values) was strictly greater than its correlations with other constructs. Furthermore, the Heterotrait-Monotrait (HTMT) ratios (upper triangular values) were all below the conservative 0.85 threshold, providing additional robust confirmation that all constructs are truly distinct from one another. [52] Overall, these results demonstrate that the measurement instruments are both reliable and valid, providing a sound basis for progressing to the structural model analysis.

Table 4. *Discriminant validity assessment (Fornell-Larcker criterion and Heterotrait-Monotrait (HTMT))*

	AV	BI	BV	EW	SOTPA
AV	**0.826**	0.397	0.823	0.719	0.343
BI	0.331	**0.816**	0.283	0.454	0.751
BV	0.722	0.240	**0.847**	0.706	0.398
EW	0.549	0.341	0.550	**0.783**	0.466
SOTPA	0.280	0.612	0.329	0.342	**0.781**

5.5. Common Method Variance

Common method variance was assessed using Harman's single-factor test. All 19 measurement items were entered into an unrotated exploratory factor analysis using principal component analysis. The results indicated that four factors with eigenvalues greater than 1 were extracted, and the first factor accounted for only 36.348% of the total variance, which is below the 50% threshold. Therefore, common method variance is unlikely to be a serious concern in this study [53], [54].

5.6. Variance Inflation Factor

Multicollinearity was assessed using the Variance Inflation Factor (VIF), as recommended by Hair et al. [50]. The VIF values for all indicators range from 1.282 to 2.331, which are well below the conservative threshold of 3.3. Specifically, the VIF values for Altruistic Value (AV) range from 1.567 to 2.100, Pro-environmental Behavioral Intention (BI) from 1.660 to 1.966, Biospheric Value (BV) from 1.905 to 2.331, Ecological Worldview (EW) from 1.282 to 1.403, and Sense of Obligation to Take Pro-environmental Actions (SOTPA) from 1.404 to 1.710. These results indicate that multicollinearity is not a concern in the model, and that the indicators do not exhibit problematic levels of collinearity. Therefore, the constructs can be considered sufficiently distinct for subsequent analysis.

5.7. Structural Model

The model's explanatory power was assessed using adjusted R^2. It explains 37.4% of the variance in BI, 34.6% in EW, and 13.7% in SOTPA. Following Chin, BI and EW show moderate explanatory power, while SOTPA is relatively weak [58].

Hypotheses were tested using standardized path coefficients (β), with significance determined by bootstrapped t-values and p-values at the 0.05 level.

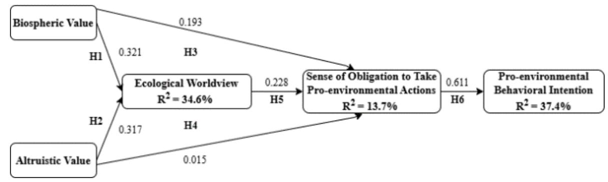

Figure 2. *The results of the PLS-SEM analysis*

The role of Self-transcendent Value orientation on Ecological Worldview. The results show that both Self-transcendent Value orientation positively and significantly shape EW. AV has a significant positive effect on EW (β = 0.317, p = 0.000), and BV also exerts a significant positive influence (β = 0.321, p = 0.000). Therefore, the hypotheses linking AV → EW (**H2**) and BV → EW (**H1**) are supported, with BV showing a slightly stronger contribution.

From Self-transcendent Value orientation and beliefs to personal norm (SOTPA). For the direct value-to-norm paths, BV significantly increases SOTPA (β = 0.193, p = 0.014), supporting **H3**, whereas AV does not show a meaningful direct effect on SOTPA (β = 0.015, p = 0.870), leading to the rejection of **H4**. Regarding SOTPA, the model indicates a clear belief-to-norm mechanism: EW → SOTPA is positive and significant (β = 0.228, p = 0.001), supporting **H5**.

Personal norm (SOTPA) and Pro-environmental Behavioral Intention (BI), including controls. SOTPA emerges as the key driver of BI, showing the strongest and highly significant effect in the structural model (β = 0.611, p = 0.000), thus supporting **H6**. For control variables predicting BI, age (β = -0.061, p = 0.246), gender (β = -0.013, p = 0.785), and monthly income (β = -0.018, p = 0.751) are not significant; education is positive but only marginal (β = 0.095, p = 0.053).

Table 6. *Structural model estimates*

Hypothesis	Path	β	p-values	T-Statistic	Results
H1	BV→EW	0.321	0.000	3.945	Supported
H2	AV→EW	0.317	0.000	4.043	Supported
H3	BV→SOTPA	0.193	0.014	2.464	Supported
H4	AV→SOTPA	0.015	0.870	0.164	Not Supported
H5	EW→SOTPA	0.228	0.001	3.274	Supported
H6	SOTPA→BI	0.611	0.000	14.011	Supported

5.8. The mediating role of constructs in VBN model

In this study, the mediating mechanisms of the VBN model were further examined to understand how Self-transcendent Value orientation is translated into Pro-environmental Behavioral Intention. Utilising bootstrapping with 5,000 resamples, the research confirms the sequential structural pathways proposed by the VBN framework through specific indirect effects.

First, EW acts as a fundamental bridge linking Self-transcendent Value orientation to moral obligation. Specifically, both BV and AV exert a notable indirect influence on SOTPA through the mediation of EW ($\beta = 0.073$, $t = 2.258$, $p < 0.01$; and $\beta = 0.072$, $t = 2.639$, $p < 0.05$, respectively). This suggests that these values do not directly trigger personal norm but first shape how individuals view environmental issues. When people develop a stronger EW, they are more likely to feel responsible for taking action.

Second, SOTPA serves as a key link between EW and BI ($\beta = 0.140$, $t = 3.156$, $p = 0.002$), supporting that Pro-environmental Behavioral Intention for WTV Food emerges only when awareness is internalized into a sense of personal responsibility.

Third, BV demonstrates a robust indirect influence on BI through SOTPA ($\beta = 0.118$, $t = 2.440$, $p < 0.05$), confirming that biospheric concerns directly trigger a sense of moral obligation. In contrast, the indirect effect of AV on BI through SOTPA is negligible and statistically insignificant ($\beta = 0.009$, $t = 0.160$, $p = 0.873$), indicating that altruistic motivations fail to activate personal norm in isolation. This lack of significance is primarily attributable to the unsupported direct link between AV and SOTPA. This stems from the fact that, unlike BV, which is inherently tied to environmental duty, AV does not instinctively foster SOTPA, as it focuses on human welfare. Instead, its influence is entirely contingent upon a prior recognition of EW.

Finally, Self-transcendent Value orientation successfully drives BI when they are translated step by step through intermediate variables, reinforcing the overall structure of the VBN model. Specifically, the multi-stage indirect effects for both BV ($\beta = 0.045$, $t = 2.249$, $p < 0.05$) and AV ($\beta = 0.044$, $t = 2.479$, $p < 0.05$) via the EW and SOTPA pathway are significant.

5.9. Discussions

First, the results confirm the significant role of Biospheric Value and Altruistic Value in shaping Ecological Worldview, consistent with prior studies Han et al. [45], Wu, L., and Zhu, Y. [59], Sharmar and Gupta [60], and Megeirhi et al. [61]. These findings suggest that Self-transcendent Value orientation play an important role in forming Ecological Worldview, as individuals who prioritize environmental protection and societal well-being are more likely to develop a worldview centered on sustainability. Applying the context of WTV Food, this relationship suggests that consumers who hold strong Biospheric and Altruistic Values are more likely to perceive environmental protection as both ecological and social responsibility. This is particularly relevant in Vietnam’s collectivist cultural orientation, where environmental issues are often framed in terms of societal concerns. As a result, these values contribute to strengthening customers’ Ecological Worldview, supporting more favourable perceptions of WTV Food as an environmentally meaningful solution.

Second, the study provides clearer insight into how Biospheric Value and Altruistic Value have a significant impact on Sense of Obligation to Take Pro-environmental Actions. Specifically, the study’s findings are consistent with earlier ones of Zeiske et al. [62] and Ateş [63], who found that Biospheric Value plays a significant role in shaping individuals' personal norm. In the WTV Food context, this relationship may be explained by the visibility of environmental benefits such as food waste reduction and resource efficiency. When such benefits are perceived as direct and tangible, Biospheric Value may more readily translate into a Sense of Obligation to Take Pro-environmental Actions. However, no significant relationship is found between Altruistic Value and Sense of Obligation to Take Pro-environmental Actions. This finding contracts with prior studies by Nguyen et al. [64] and Yuen et al. [65], suggesting that altruistic concerns for societal well-being can directly translate into personal norm. This contrasting result may be explained by the specific characteristics of WTV Food, where perceived personal costs or discomfort weakens the formation of personal norm. As a result, even when consumers recognize the societal benefits of reducing food waste, they may hesitate to internalize these concerns as a Sense of Obligation to Take Pro-environmental Actions.

Finally, the findings provide an explanation of the relationship from Ecological Worldview to Sense of Obligation to Take Pro-environmental Actions and Pro-environmental Behavioral Intention. Consistent with previous studies of Gkargkavouzi et al. [66] and Wu [67], Ecological Worldview is found to significantly influence individuals’ Sense of Obligation to Take Pro-environmental Actions. This result suggests that when individuals recognize the environmental consequences of human activities, they are more likely to feel a sense of obligation to adopt WTV Food. This process reflects how environmental beliefs are translated into personal norm. Furthermore, the positive relationship between Sense of Obligation to Take Pro-environmental Actions and Pro-environmental Behavioral Intention was supported by Song et al. [68] and Zhang et al. [69]. This finding highlights the central role of moral obligation in shaping Pro-environmental Behavioral Intention, as suggested by the VBN model. In the context of WTV Food, this relationship implies that the intention to adopt such products may be influenced not only by practical considerations but also by a deeper sense of responsibility toward environmental sustainability.

6. Implication and Limitations

6.1. Implication

6.1.1. Theoretical Implication

This study contributes to the pro-environmental behavior literature by reinforcing and refining the VBN framework within Vietnam's WTV Food context.

First, our primary theoretical contribution centers on the differential pathways from values to Sense of Obligation to Take Pro-environmental Actions: Biospheric Value directly activates personal norm when environmental benefits are tangible [62], [63], while Altruistic Value shows no direct effect - contrasting prior findings of direct altruism-to-norm transformation in collectivist settings [64], [65]. This highlights a novel boundary condition in WTV Food: specific characteristics such as individual cost or inconvenience may disrupt altruism’s path to obligation, requiring mediation via Ecological Worldview and contributing significantly to VBN framework by revealing context-dependent value activation for high-compromise pro-environmental behaviors [8], [17].

Second, the findings confirm the foundational role of Self-transcendent Value orientation including Biospheric and Altruistic Values in shaping Ecological Worldview [20]. This supports the theoretical assumption that value orientations function as stable guiding principles that influence individuals’ environmental beliefs [22], [19], [9], thereby strengthening the argument that pro-environmental cognition is rooted in deeper moral value structures [32].

Third, the results validate the sequential pathway from Ecological Worldview to Sense of Obligation to Take Pro-environmental Actions, and subsequently to Pro-environmental Behavioral Intention. This aligns with the norm-activation logic that environmental beliefs translate into Pro-environmental Behavioral Intention primarily through the internalization of personal moral obligation [8], [17].

6.1.2. Practical Implication

The findings of this study provide several practical implications for policymakers, agri-food businesses, and practitioners aiming to promote the adoption of WTV Food in Vietnam.

First, communication strategies should position WTV Food as a meaningful consumption choice that reflects personal values and social responsibility. For example, marketing campaigns can highlight how choosing WTV Food contributes to food waste reduction, natural resources protection, and community well-being support. In practice, businesses could integrate storytelling approaches into branding, such as showcasing how surplus food is transformed into valuable products, thereby making environmental benefits more tangible and emotionally engaging for consumers.

Second, agri-food firms should design product and customer experience strategies that simultaneously attract both moral motivations and personal benefits. While sustainability messaging is important, consumers are also strongly influenced by taste, convenience, and perceived value. Therefore, businesses should ensure that WTV products meet high standards of quality, sensory appeal and affordability. For instance, restaurants and food stores could frame WTV dishes as trendy, innovative and enjoyable options rather than simply “sustainable alternatives”, thereby increasing their attractiveness to a broader consumer base.

Third, policymakers and industry stakeholders should implement educational programs (such as promoting zero-waste meals or circular food initiatives on campus) that translate environmental awareness into real consumer actions. For example, public campaigns could include promoting strategies such as eco-labeling for WTV products, or default menu options that feature WTV Food.

Finally, policymakers could provide incentives for businesses that invest in food upcycling technologies, develop clear certification systems for WTV products, and support supply chain coordination between producers, retailers and food service providers. These efforts would reduce barriers for firms while increasing consumer trust and acceptance of WTV Food in the market.

6.2. Limitations

This study has several limitations. The relatively small and age-concentrated sample, along with the single-country context (Vietnam), may limit generalizability. In addition, the reliance on self-reported survey data also raises the possibility of response bias. Theoretically, the model focuses mainly on internal determinants within the VBN framework and does not capture contextual influences on WTV Food adoption. Furthermore, the absence of strict screening criteria may lead to variability in respondents’ prior knowledge and perceptions of WTV Food, potentially affecting response consistency. Moreover, not all value orientations and the belief dimensions were comprehensively operationalized. Future research may incorporate Self-interest Value orientation and belief constructs, as well as potential mediators or moderators, to enhance explanatory power and aversion of intrinsic values on Pro-environmental Behavioral Intention.

7. Conclusion

Given the growing importance of Waste-to-Value Food in promoting sustainable consumption, this study examined how Self-transcendent Value orientation influences consumers' Pro-environmental Behavioral Intention through a sequential mediating chain of Ecological Worldview and personal norm within the Value-Belief-Norm framework. The findings clarify the moral and psychological drivers underlying Pro-environmental Behavioral Intention in the Vietnamese context, thereby contributing to the literature on value-driven sustainable consumption in emerging markets. Practically, the results provide guidance for firms and food producers in designing value-based communication and development strategies to effectively promote WTV Food in Vietnam.

REFERENCES

[1] United Nations Environment Programme, "*Food Waste Index Report,*" United Nations Environment Programme (UNEP), Nairobi, Kenya, Research Report, 2021.

[2] Food and Agriculture and Organization of the United Nations., "*FAO Regional Strategy on Food Loss and Waste Reduction in Asia and the Pacific*," FAO., 2022b.

[3] EC, "Behavioural study on consumers' engagement in the circular economy," *Rep. N° CHAFEA2015CP01 Dir.-Gen. Justice Consum. Eur. Comm.*, 2018.

[4] J. Aschemann-Witzel and A. O. Peschel, "How circular will you eat? The sustainability challenge in food and consumer reaction to either waste-to-value or yet underused novel ingredients in food," *Food Qual. Prefer.*, vol. 77, pp. 15–20, 2019.

[5] S. Bhatt, J. Lee, J. Deutsch, H. Ayaz, B. Fulton, and R. Suri, "From food waste to value-added surplus products (VASP): Consumer acceptance of a novel food product category", *Journal of Consumer Behaviour*, vol. 17, no. 1, pp. 57–63, 2018. https://doi.org/10.1002/cb.1689

[6] R. Santagata, M. Ripa, A. Genovese, and S. Ulgiati, "Food waste recovery pathways: Challenges and opportunities for an emerging bio-based circular economy. A systematic review and an assessment," *J. Clean. Prod.*, vol. 286, p. 125490, 2021.

[7] F. Cicculllo, R. Cagliano, G. Bartezzaghi, and A. Perego, "Implementing the circular economy paradigm in the agri-food supply chain: The role of food waste prevention technologies," *Resour. Conserv. Recycl.*, vol. 164, p. 105114, 2021.

[8] P. C. Stern, "New environmental theories: toward a coherent theory of environmentally significant behavior," *J. Soc. Issues*, vol. 56, no. 3, pp. 407–424, 2000.

[9] L. Steg and C. Vlek, "Encouraging pro-environmental behaviour: An integrative review and research agenda," *J. Environ. Psychol.*, vol. 29, no. 3, pp. 309–317, 2009.

[10] Q. C. Nguyen, T. Næs, D. Asioli, V. V. M. Le, and P. Varela, "Consumer preferences for upcycled foods: The role of product attributes and label information," *Food Qual. Prefer.*, vol. 133, p. 105611, 2025. DOI: 10.1016/j.foodqual.2025.105611

[11] J. Aschemann-Witzel and I. D. C. Stangherlin, "Upcycled by-product use in agri-food systems from a consumer perspective: A review of what we know, and what is missing," *Technol. Forecast. Soc. Change*, vol. 168, p. 120749, Jul. 2021, doi: 10.1016/j.techfore.2021.120749.

[12] S. Coderoni and M. A. Perito, "Sustainable consumption in the circular economy. An analysis of consumers' purchase intentions for waste-to-value food," *J. Clean. Prod.*, vol. 252, p. 119870, Apr. 2020, doi: 10.1016/j.jclepro.2019.119870.

[13] D. A. Teigiserova, L. Hamelin, and M. Thomsen, "Towards transparent valorization of food surplus, waste and loss: Clarifying definitions, food waste hierarchy, and role in the circular economy," *Sci. Total Environ.*, vol. 706, p. 136033, Mar. 2020, doi: 10.1016/j.scitotenv.2019.136033.

[14] U. F. D. T. Force, "Defining upcycled foods: A definition for use across industry, government, and academia," *Denver CO Upcycled Food Assoc.*, vol. 20, 2020.

[15] J. Aschemann-Witzel, D. Asioli, M. Banovic, M. A. Perito, A. O. Peschel, and V. Stancu, "Defining upcycled food: The dual role of upcycling in reducing food loss and waste," *Trends Food Sci. Technol.*, vol. 132, pp. 132–137, 2023.

[16] European Commission, "*Resilience and Transformation: Report of the 5th SCAR Foresight Exercise Expert Group – Natural Resources and Food Systems: Transitions towards a 'Safe and Just' Operating Space",* Publications Office of the European Union, Luxembourg, Luxembourg, Independent Expert Report, 2020.

[17] J. I. De Groot and L. Steg, "Morality and prosocial behavior: The role of awareness, responsibility, and norms in the norm activation model*," J. Soc. Psychol.,* vol. 149, no. 4, pp. 425–449, 2009.

[18] S. H. Schwartz, "Normative influences on altruism," in Advances in experimental social psychology, vol. 10, Elsevier, 1977, pp. 221–279.

[19] S. H. Schwartz and J. A. Howard, "A normative decision-making model of altruism," Altruism Help. Behav., pp. 189–211, 1981.

[20] R. E. Dunlap, K. D. Van Liere, A. G. Mertig, and R. E. Jones, "New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: a revised NEP scale," J. Soc. Issues, vol. 56, no. 3, pp. 425–442, 2000.

[21] M. C. Onwezen, G. Antonides, and J. Bartels, "The Norm Activation Model: An exploration of the functions of anticipated pride and guilt in pro-environmental behaviour," J. Econ. Psychol., vol. 39, pp. 141–153, 2013.

[22] P. C. Stern, T. Dietz, T. Abel, G. A. Guagnano, and L. Kalof, "A value-belief-norm theory of support for social movements: The case of environmentalism," Hum. Ecol. Rev., pp. 81–97, 1999.

[23] C. J. van Riper, C. Lum, G. T. Kyle, K. E. Wallen, J. Absher, and A. C. Landon, "Values, motivations, and intentions to engage in proenvironmental behavior," Environ. Behav., vol. 52, no. 4, pp. 437–462, 2020.

[24] L. Steg, J. W. Bolderdijk, K. Keizer, and G. Perlaviciute, "An integrated framework for encouraging pro-environmental behaviour: The role of values, situational factors and goals," *J. Environ. Psychol.*, vol. 38, pp. 104–115, 2014.

[25] J. De Groot, L. Steg, and M. Dicke, "Morality and reducing car use: testing the norm activation model of prosocial behavior," *Transp. Res. Trends NOVA Publ*., vol. 2, no. 1, pp. 12–32, 2007.

[26] Han, H., Hwang, J., Kim, J., and Jung, H., "Guests' pro environmental decision-making process: Broadening the norm activation framework in a lodging context.," *Int. J. Hosp. Manag*., vol. 47, pp. 96–107, 2015, doi: 10.1016/j.ijhm.2015.03.013.

[27] N. López-Mosquera and M. Sánchez, "Theory of Planned Behavior and the Value-Belief-Norm Theory explaining willingness to pay for a suburban park," *J. Environ. Manage*., vol. 113, pp. 251–262, Dec. 2012, doi: 10.1016/j.jenvman.2012.08.029.

[28] F. Agissova and E. Sautkina, "The Role of Personal and Political Values in Predicting Environmental Attitudes and Pro-environmental Behavior in Kazakhstan*," Front. Psychol*., vol. 11, Dec. 2020, doi: 10.3389/fpsyg.2020.584292.

[29] A. Al Mamun, N. Hayat, M. M. Masud, Z. K. M. Makhbul, T. Jannat, and M. F. M. Salleh, "Modelling the Significance of Value-Belief-Norm Theory in Predicting Solid Waste Management Intention and Behavior," *Front. Environ. Sci.,* vol. 10, Aug. 2022, doi: 10.3389/fenvs.2022.906002.

[30] De Groot, J. I. and Steg, L., "Value orientations to explain beliefs related to environmental significant behavior: How to measure egoistic, altruistic, and Biospheric Value orientations.," *Environ. Behav*., vol. 40, no. 3, 2008.

[31] C. J. Van Riper and G. T. Kyle, "Understanding the internal processes of behavioral engagement in a national park: A latent variable path analysis of the value-belief-norm theory," *J. Environ. Psychol.,* vol. 38, pp. 288–297, 2014.

[32] A. M. Nordlund and J. Garvill, "Value Structures behind Proenvironmental Behavior," *Environ. Behav.,* vol. 34, no. 6, pp. 740–756, Nov. 2002, doi: 10.1177/001391602237244.

[33] Q.-C. Wang, Y.-N. Lou, X. Liu, X. Jin, X. Li, and Q. Xu, "Determinants and mechanisms driving energy-saving behaviours of long-stay hotel guests: Comparison of leisure, business and extended-stay residential cases," *Energy Rep*., vol. 9, pp. 1354–1365, Dec. 2023, doi: 10.1016/j.egyr.2022.12.051.

[34] A. Chakraborty, M. P. Singh, and M. Roy, "Educators' value orientations endorsing their willingness to participate in sustainable activities: A study from Indian higher education institutions," *Stud. High. Educ*., vol. 46, no. 6, pp. 1025–1040, Jun. 2021, doi: 10.1080/03075079.2019.1666260.

[35] J. Thøgersen, "Norms for environmentally responsible behaviour: An extended taxonomy," *J. Environ. Psychol.,* vol. 26, no. 4, pp. 247–261, Dec. 2006, doi: 10.1016/j.jenvp.2006.09.004.

[36] J. Hwang, W. Kim, and J. J. Kim, "Application of the value-belief-norm model to environmentally friendly drone food delivery services: The moderating role of product involvement," *Int. J. Contemp. Hosp. Manag*., vol. 32, no. 5, pp. 1775–1794, Apr. 2020, doi: 10.1108/IJCHM-08-2019-0710.

[37] L. Wang, Z.-X. Wang, Q. Zhang, A. Jebbouri, and P. P. W. Wong, "Consumers' intention to visit green hotels – a goal-framing theory perspective," *J. Sustain. Tour.*, vol. 30, no. 8, pp. 1837–1857, May 2022, doi: 10.1080/09669582.2021.1977937.

[38] H.-W. Jang, "How important is human service for sustainable restaurant businesses?" *J. Hosp. Tour. Manag.*, vol. 48, pp. 406–415, Sep. 2021, doi: 10.1016/j.jhtm.2021.07.017.

[39] A. B. Ünal, L. Steg, and J. Granskaya, "'To support or not to support, that is the question'. Testing the VBN theory in predicting support for car use reduction policies in Russia," *Transp. Res. Part Policy Pract.*, vol. 119, pp. 73–81, 2019.

[40] K. Rezaei-Moghaddam, N. Vatankhah, and A. Ajili, "Adoption of pro-environmental behaviors among farmers: application of Value–Belief–Norm theory," *Chem. Biol. Technol. Agric.*, vol. 7, no. 1, p. 7, Apr. 2020, doi: 10.1186/s40538-019-0174-z.

[41] D. L. Hoeksma, M. A. Gerritzen, A. M. Lokhorst, and P. M. Poortvliet, "An extended theory of planned behavior to predict consumers' willingness to buy mobile slaughter unit meat," *Meat Sci.*, vol. 128, pp. 15–23, 2017.

[42] Iriyadi, B. Setiawan, and R. Puspitasari, "Consumer intentions to reduce food waste in all-you-can-eat restaurants based on personal norm activation," *Heliyon*, vol. 9, no. 2, Feb. 2023, doi: 10.1016/j.heliyon.2023.e13399.

[43] A. Al Mamun, Y. Ma, M. N. H. Reza, J. Ahmad, H. W. M. H. Wan, and Z. Lili, "Predicting attitude and intention to reduce food waste using the environmental values-beliefs-norms model and the theory of planned behavior," *Food Qual. Prefer.*, vol. 120, p. 105247, 2024.

[44] A. Bryman and E. Bell, *Business research methods 3e*. Oxford university press, USA, 2011.

[45] H. Han, J. Hwang, and M. J. Lee, "The value–belief–emotion–norm model: Investigating customers' eco-friendly behavior," *J. Travel Tour. Mark.*, vol. 34, no. 5, pp. 590–607, 2017.

[46] L. Steg and J. I. De Groot, "Environmental values," in *The Oxford handbook of environmental and conservation psychology*, Oxford University Press, 2012, pp. 81–92.

[47] M. Cordano, S. Welcomer, R. F. Scherer, L. Pradenas, and V. Parada, "A cross-cultural assessment of three theories of pro-environmental behavior: A comparison between business students of Chile and the United States," *Environ. Behav.*, vol. 43, no. 5, pp. 634–657, 2011.

[48] C. J. Wynveen, B. J. Wynveen, and S. G. Sutton, "Applying the value-belief-norm theory to marine contexts: Implications for encouraging pro-environmental behavior," *Coast. Manag.*, vol. 43, no. 1, pp. 84–103, 2015.

[49] D. T. Campbell and D. W. Fiske, "Convergent and discriminant validation by the multitrait-multimethod matrix.," *Psychol. Bull.*, vol. 56, no. 2, p. 81, 1959.

[50] J. F. Hair, J. J. Risher, M. Sarstedt, and C. M. Ringle, "When to use and how to report the results of PLS-SEM," *Eur. Bus. Rev.*, vol. 31, no. 1, pp. 2–24, 2019.

[51] J. C. Nunnally, *Psychometric Theory*, 2nd edition. New York, NY: McGraw-Hill Book Company, 1978

[52] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *J. Mark. Res.*, vol. 18, no. 1, pp. 39–50, 1981.

[53] H. H. Harman, *Modern Factor Analysis*, 3rd ed. Chicago, IL, USA: University of Chicago Press, 1976.

[54] P. M. Podsakoff, S. B. MacKenzie, J. Y. Lee, and N. P. Podsakoff, "Common method biases in behavioral research: A critical review of the literature and recommended remedies," *Journal of Applied Psychology*, vol. 88, no. 5, pp. 879–903, 2003.

[55] L. R. Fabrigar and D. T. Wegener, *Exploratory factor analysis*. Oxford University Press, 2012.

[56] C. D. Dziuban and E. C. Shirkey, "When is a correlation matrix appropriate for factor analysis? Some decision rules.," *Psychol. Bull.*, vol. 81, no. 6, p. 358, 1974.

[57] J. F. Hair, W. C. Black, B. J. Babin, and R. E. Anderson, *Multivariate Data Analysis*, 8th edition. Andover, Hampshire, UK: Cengage Learning EMEA, 2019.

[58] W. W. Chin, "Commentary: Issues and opinion on structural equation modeling," *MIS quarterly*. JSTOR, pp. vii–xvi, 1998.

[59] L. Wu and Y. Zhu, "How love of nature promotes green consumer behaviors: The mediating role of Biospheric Values, ecological worldview, and personal norms," *PsyCh J.*, vol. 10, no. 3, pp. 402–414, 2021.

[60] R. Sharma and A. Gupta, "Pro-environmental behaviour among tourists visiting national parks: Application of value-belief-norm theory in an emerging economy context," *Asia Pac. J. Tour. Res.*, vol. 25, no. 8, pp. 829–840, 2020.

[61] H. A. Megeirhi, K. M. Woosnam, M. A. Ribeiro, H. Ramkissoon, and T. J. Denley, "Employing a value-belief-norm framework to gauge Carthage residents' intentions to support sustainable cultural heritage tourism," *J. Sustain. Tour.*, vol. 28, no. 9, pp. 1351–1370, 2020.

[62] N. Zeiske, L. Venhoeven, L. Steg, and E. van der Werff, "The Normative Route to a Sustainable Future: Examining Children's Environmental Values, Identity and Personal Norms to Conserve Energy," *Environ. Behav.*, vol. 53, no. 10, pp. 1118–1139, Dec. 2021, doi: 10.1177/0013916520950266.

[63] H. Ateş, "Merging Theory of Planned Behavior and Value Identity Personal norm model to explain pro-environmental behaviors," *Sustain. Prod. Consum.*, vol. 24, pp. 169–180, Oct. 2020, doi: 10.1016/j.spc.2020.07.006.

[64] T. N. Nguyen, A. Lobo, and S. Greenland, "The influence of Vietnamese consumers' altruistic values on their purchase of energy efficient appliances," *Asia Pacific Journal of Marketing and Logistics*, vol. 29, no. 4, pp. 759–777, 2017, doi: 10.1108/APJML-08-2016-0151.

[65] Y. Y. Yee, P. H. P. Yeow, and W. Loo, "A cross-sectional survey measuring social norms, personal norms and altruistic values across responsible computer consumption life cycles," *F1000Research*, vol. 12, p. 1575, 2023, doi: 10.12688/f1000research.139037.1.

[66] A. Gkargkavouzi, G. Halkos, and S. Matsiori, "Environmental behavior in a private-sphere context: Integrating theories of planned behavior and value belief norm, self-identity and habit," *Resour. Conserv. Recycl.*, vol. 148, pp. 145–156, Sep. 2019, doi: 10.1016/j.resconrec.2019.01.039.

[67] L. Wu, "The relationships between environmental sensitivity, ecological worldview, personal norms and pro-environmental behaviors in Chinese children: Testing the value–belief–norm model with environmental sensitivity as an emotional basis", *Psych Journal*, vol. 7, no. 2, pp. 111–121, 2018.

[68] J. Song, L. Cai, K. F. Yuen, and X. Wang, "Exploring consumers' usage intention of reusable express packaging: An extended norm activation model," *J. Retail. Consum. Serv.*, vol. 72, p. 103265, 2023.

[69] L. Zhang, Y. Yin, L. Liu, and S. Yang, "Exploring the effects of AR presence and personal norms on museum visitor pro-environmental behaviour intentions," Sci. Rep., vol. 15, no. 1, p. 25633, 2025.

[70] P. T. Nhung, V. Q. Tri, H. L. T. Truong, and N. T. P. Nhi, "Factors Affecting Online Purchasing Behavior of Organic Food: Study at Danang City". *The University of Danang - Journal of Science and Technology*, vol. 21, no. 8.1, pp. 1–11, 2023.

[71] N. K. Nam, "Organic Food Purchasing Behavior of Young Consumers: The Role of Trust". *The University of Danang - Journal of Science and Technology*, vol. 8, no. 93, pp. 104–108, 2015.