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Clustering Koreans' Environmental Awareness and Attitudes into Seven Groups: Environmentalists, Dissatisfieds, Inactivators, Bystanders, Honeybees, Optimists, and Moderates

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Abstract: We attempted to characterize different groups of environmental awareness and attitudes and to interpret the public's diverse interests in the environment. Responses of a five-year public survey in South Korea were clustered by *k*-means algorithms into the following seven groups: environmentalists, dissatisfieds, inactivators, bystanders, honeybees, optimists, and moderates. The environmentalists, who were dissatisfied with the status of the environment, had a strong orientation toward pro-environmental attitudes and practices. The inactivators revealed a discrepancy between high orientation in pro-environmental perception and attitude and weak participation in pro-environmental practices. The optimists and dissatisfieds stood distinct against each other, while the former were satisfied with the status of the environment and the environmental protection efforts of government and enterprises, the latter were not. The honeybees, who were older than others, had little knowledge of the environment but engaged in more environmental protection practices; the younger bystanders were less interested in environmental issues and practices. The moderates gave average answers to the overall questions. Cluster analysis could help in understanding the complex landscape of the public's environmental awareness and attitudes beyond a straightforward scale from anti- to pro-environment and support the establishment of environmental policy customized to the different groups.

Keywords: public survey; *k*-means cluster; new environmental paradigm; customized environmental policy

1. Introduction

People have heterogeneous thoughts. These thoughts are invisible and sometimes ambiguous, conflicting, and inconsistent; nevertheless, they shape a society and policy decisions. There is thus an urgent need to identify the public's opinion to build a foundation for policy formulation and decision-making [1]. Public surveys play a significant role in unveiling the public opinion hidden under the surface.

People's awareness and attitudes toward the environment have previously been a target of public surveys. Such surveys have been conducted not only at the national level, such as in the United States [2], the United Kingdom [3], Germany [4], and Japan [5,6], but also at the multinational level, such as in European countries [7], 10 ASEAN countries [8], and 33 global countries [9]. Eurobarometer has published reports in the series "Attitudes of European Citizens towards the Environment" (prior to 1999, "Europeans and Their Environment") 15 times since 1982, and in the series on nuclear safety, six times from 1998 to 2009 [10], providing information on different opinions and their temporal changes

among up to 28 European countries. Such surveys raise the awareness of decision makers, academics, and the public on the standards and trends concerning people's thoughts on the environment.

However, these surveys have not focused on the heterogeneity of people's environmental awareness and attitudes. In a society, heterogeneous opinions are shaped by both (1) various socioenvironmental factors and contexts and (2) personal beliefs and life history, however are generally aggregated into a single value representative of a country or a particular sociodemographic group (e.g., sex, generation, age, region, class, etc.). For example, a Eurobarometer 2014 survey reported that "85% of Europeans believe they can play a role in protecting the environment" [7] (p. 20), with differences in the values of the 28 EU countries and various sociodemographic groups. This kind of descriptive analysis of public surveys is not without value; nevertheless, understanding the heterogeneity of environmental awareness and attitudes not represented by nationality or sociodemographic group could be useful in grasping the perception and interests of customized stakeholder groups regarding environmental issues. It could be interesting to assess, for example, the heterogeneity of the "85% of Europeans" who believe they can play a role in protecting the environment; they may have differing motivations, values, or sociodemographic circumstances.

Here, cluster analysis can be applied to analyze the in-depth environmental awareness and attitudes of the public. Cluster analysis investigates homogeneous groups in data based on (dis)similarity of data points by hierarchical methods, or based on minimized within-cluster variation by partitioning methods (e.g., *k*-means method). Since the 1950s, cluster analysis has been extensively used in marketing studies to identify groups of customers and clients with similar needs, values, or motivations; this allows for designing customized marketing strategies for distinct customer groups [11–13]. Unlike the empirical agreement of market segmentation strategy using cluster analysis, its theoretical foundation has been neither concrete nor commonly agreed upon [14]. Hunt & Arnett [14] introduced resource-advantage theory as a theoretical foundation of market segmentation strategy; the theory assumed that heterogeneous demand leading to intra-firm competition induces superior financial performance. Cluster analysis is also popular in biological studies, and it is used to identify genes from gene expression data at a molecular level e.g., [15,16] or to classify species from visible traits at an organism level [17,18].

Cluster analysis in marketing studies has been extended to various social sciences not only to classify social groups as biological studies do [19] but also to design communication strategy for behavior change, which is called social marketing [20]. For example, since 1987, the Pew Research Center has been reporting American political typology groups using cluster analysis, to investigate people's complex political attitudes, moving beyond the dichotomy of left vs. right or Republicans vs. Democrats toward nine groups with multidimensional classification [21]. The public health sector adopted the social marketing approach to design policy intervention for promoting healthy behaviors by clustering health attitudes, perception, behavior, and so on [22,23]. "Segmen[ting], tailoring, and targeting" [20] (p. 443) audiences of marketing, politics, public health programs, etc. could elaborate messages capturing particular interests and motivations of different audience groups.

Within environmental sectors, the climate change sector has led to the audience segmentation approach [20]. The Yale Project on Climate Change Communication program has identified six groups of awareness and attitudes toward climate change in Americans [24,25], including alarmed, concerned, cautious, disengaged, doubtful, and dismissive. This approach was adopted to cases of Indians [26], Australians [27], and Germans [28]. In addition, AP-NORC [2] in collaboration with the Yale group clustered Americans' attitudes toward the environment into nine groups. Hine et al. [20], which reviewed trends, conceptual consideration, methodological issues, and further challenges of audience segmentation studies in climate change communication, not only demonstrated the advantages of the audience segmentation approach but also encouraged more advanced studies in terms of strengthened theoretical foundation of segmentation and validated effects of communication strategy by segmentation.

In South Korea, since 2012, a public survey program for awareness and attitudes toward the environment (PSAAE) has been conducted annually by the Korea Environment Institute. Every year, descriptive results on approximately 60 questions with differences by sociodemographic groups (e.g., sex, age class, region, education level, etc.) have been reported. One thousand sets of annually accumulated responses were supposed not only to report inter-annual trends on the surveyed data, but also to elucidate an in-depth understanding of the structure, interactions, and dynamics of public's awareness and attitudes toward the environment, which remains hidden under the surface of the reported values. Here, the audience clustering approach would demonstrate an advanced application of the PSAAE.

This study aimed to identify South Korean public opinion groups on environmental awareness and attitudes by using cluster analysis on data acquired from a five-year public survey with 5000 respondents. In particular, we investigated the following questions: How can the groups of environmental awareness and attitudes among Koreans be divided? What factors define the principal differences among these groups? What in-depth knowledge regarding people's environmental awareness and attitudes can cluster analysis present, beyond pro- vs. anti-environmentalism?

2. Materials and Methods

The PSAAE aims to communicate the public's opinion on the environment and to support policy development. In each year's survey, approximately 60 questions—from a structured questionnaire—are asked face-to-face to 1000 respondents (aged 20 to 70), who represent the South Korean adult population distribution by sex, region, and age class, through a multistage stratified sampling design (Table A1). Respondents were independently selected for each year's survey. Consequently, approximately 5000 different respondents were taken from the annual surveys from 2013 to 2017. In the annual survey, the sampling error was ±3.1% at a 95% confidence level. Questionnaires were organized into five sections to examine environmental perception, awareness and attitudes toward the environment, practices for environmental protection, environmental policy demand, and assessment of life quality and sustainability, respectively (Figure 1). Questionnaires referred to surveys from other countries, such as Eurobarometer [7], NHK's survey in Japan [5], UK Defra's survey [3], the New Environmental Paradigm (NEP) scale [29] etc., to ensure inter-country comparability. Since 2012, most questions have remained consistent, with a few changes to ensure inter-annual consistency and comparability. In addition, one or two customized sections for issues specific to each year are included, for example algal blooms, ecosystem services, fine dust, and nuclear energy, included in 2014, 2015, 2016, and 2017, respectively. Finally, respondents' sociodemographic information (e.g., sex, age, education, and so on; Figure 1) were surveyed.

Groups of environmental awareness and attitudes were identified using cluster analysis with 25 ordinal or numeric variables. Nominal variables, such as the most concerning environmental issues or most associated image of the environment, were excluded due to the infeasibility of nonordinal variables in cluster analysis. Rather than *k*-means or hierarchical cluster analysis, latent class analysis could be applied for a mixed dataset of nominal and ordinal variables; however, latent class analysis was not performed. Because most responses in the questionnaire were designed as ordinal, loss of information by excluding nominal variables was negligible. In addition, survey data before 2013 or after 2017 were excluded due to minor changes in the questionnaire which reduced several comparable questions across multiple years. The procedures of the cluster analysis are described below.

The data in the selected 25 variables were standardized, then principal component analysis (PCA) was performed to reduce the multi-collinearity of the dataset. Principal components with eigenvalue higher than one were clustered by the *k*-means method using Hartigan–Wong's algorithm. The number of clusters (k) was set to seven, based on a preliminary test comparing the results with different numbers of clusters from four to eight. In the preliminary test, outputs of diagnostic tests by the *NbClust* package in R [30]—which produces over 20 indices to determine the best number of clusters—were examined. As a result, Hartigan index [31], Marriot index [32], Trace W index [33],

and Rubin index [34] suggested that the best number of clusters is seven, while other indices produced different results. In addition, clustering with seven clusters had the highest feasibility for interpretation in comparison to clustering with four to eight clusters. A hierarchical clustering was also done in the preliminarily test; however, this method was not selected because the results of *k*-means clustering were more feasible for interpretation. Key features of the seven clusters were interpreted based on the differences in the values among the clusters tested by analysis of variance (ANOVA) with a Scheffe post-hoc test ($p < 0.05$).

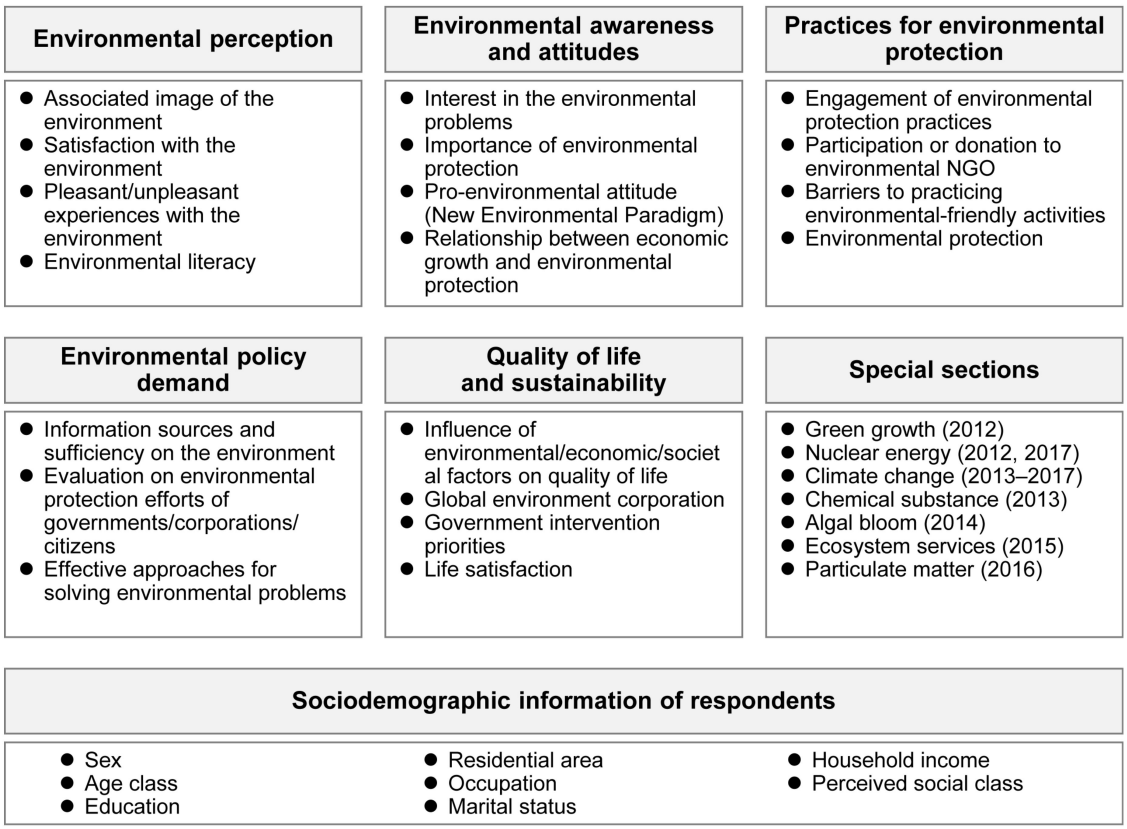

Figure 1. Questionnaire structure of the public survey on awareness and attitudes toward the environment in South Korea.

Additional analyses were performed to demonstrate applicability of the clustering approach to awareness and attitudes towards the environment. First, the relationship between environmental literacy and behavior, which were measured by the number of familiar environmental terms and environmental protection practices engaged in a list, respectively, was tested by the group of environmental awareness and attitudes. Second, responses of a question on effective means to protect environment, which is one of nominal variables in the PSAAE were compared among the groups of environmental awareness and attitudes.

All data processing, statistical tests, and visualization were done using R [35].

3. Results

3.1. Clustering Responses on Environmental Awareness and Attitudes

PCA analysis suggested eight principal components with eigenvalue higher than one, reducing the numerous dimensions. These components represented environmental protection practices (Comp. 1), evaluation of environmental protection efforts of societal sectors (e.g., governments, corporations, and citizens) (Comp. 2), influence of environmental/economic/societal factors on quality of life (Comp. 3),

environmental literacy (Comp. 4), sufficiency of environmental information (Comp. 5), satisfaction with the environment (Comp. 6), exposure to the environment (Comp. 7), and pro-economic attitudes for environmental protection (Comp. 8), explaining approximately three fifth of total variance (Table 1). For example, number of environmental protection practices (C1) and agreement on barriers to practicing environmental-friendly activities (C3–C5) were primarily loaded in Comp. 1.

Table 1. PCA on 25 ordinal variables from the public survey on awareness and attitudes toward the environment.

		Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6	Comp. 7	Comp. 8
					Eigenvalues				
	Eigenvalue	3.22	3.06	1.83	1.50	1.41	1.29	1.13	1.00
	Proportion of variance	0.13	0.12	0.07	0.06	0.06	0.05	0.05	0.04
	Cumulative proportion	0.13	0.25	0.32	0.38	0.44	0.49	0.54	0.58
					Component matrix				
A1	Satisfaction with the environment	−0.11	0.26	0.12	0.12		**0.57**		
A2	Environmental status in compared to developed countries		0.26	0.11	0.13		**0.56**		
A3	Pleasant experiences with the environment	0.11				−0.10	**0.32**	**−0.64**	−0.20
A4	Unpleasant experiences with the environment	0.16			−0.19	−0.22	−0.12	**−0.51**	**−0.32**
A5	Number of familiar environmental terms	0.20			**−0.36**	−0.23	0.17		0.22
A6	Recognition with climate change issues	0.16			−0.25	−0.25		**0.41**	
B1	Interest in environmental problems	0.25		−0.16	−0.12	−0.23	0.13	0.16	
B2	Pro−environmental attitude scale	0.24	−0.15	0.12	−0.29	0.19	0.10		0.21
B3	Environmental protection can foster economic growth	0.14	0.15		**0.34**	**−0.33**	−0.14		**0.33**
B4	Environmental protection requires economic growth		0.20	0.14	**0.41**	**−0.32**	−0.15		0.27
B5	Economic growth is always harmful to the environment		0.10		0.14	−0.18		0.27	**−0.72**
C1	Environmental protection practices	**0.31**		−0.17					
C2	Intensity of environmental protection activity	0.25	0.10	−0.25		−0.10			
C3	I don't want to practice energy−saving	**−0.35**	−0.10	0.16	−0.15	**−0.31**			
C4	I want convenience even though it is bad for the environment	**−0.34**	−0.13	0.20	−0.16	**−0.31**			
C5	I prefer fast shipping and transportation	**−0.31**	−0.12	0.19	−0.19	−0.26			0.14
D1	Sufficiency of information on the environment			−0.21	−0.08	−0.42		0.12	
D2	Central government's environmental protection efforts	−0.11	**0.40**		−0.23		−0.18		
D3	Local government's environmental protection efforts		**0.41**		−0.20		−0.18		
D4	Corporations' environmental protection efforts	−0.15	**0.37**				−0.20		
D5	NGOs' environmental protection efforts		0.29		**−0.35**	0.13			
D6	Citizens' environmental protection efforts	−0.10	**0.35**		−0.14				
E1	Influence of environmental status on quality of life	0.28	0.10	**0.37**			−0.10		
E2	Influence of economic factors on quality of life	0.21		**0.52**					
E3	Influence of societal factors on quality of life	0.23		**0.50**					

Absolute values of loading higher than 0.3 and lower than 0.1 are bolded and omitted, respectively. Refer to Table 2 for detailed descriptions of the variables and response scales.

Public awareness and attitudes toward the environment were classified into seven groups, as follows: environmentalists, dissatisfieds, inactivators, bystanders, honeybees, optimists, and moderates. The seven groups showed significantly different scores (one-way ANOVA, $p < 0.001$) in their responses to the 25 questions (Table 2) and the eight principal components (Table A2). The differences could describe the key features of each group (see Section 3.2).

Table 2. Mean scores of 25 variables by clustered environmental awareness and attitude groups.

	Questions and Responses	Environ-Mentalists	Dissat-Isfieds	Inacti-Vators	Bystan-Ders	Honeybee	Optimists	Moder-Ates
A1	Satisfaction with the environment (*1 [very unsatisfied] to 5 [very satisfied]*)	2.86 e (0.67)	**2.84 e (0.70)**	3.03 d (0.60)	3.20 c (0.64)	**3.59 a (0.62)**	3.39 b (0.62)	2.86 e (0.61)
A2	Environmental status in compared to developed countries (*1 [much worse] to 5 [much better]*)	**2.47 e (0.75)**	2.53 de (0.82)	2.63 d (0.69)	2.79 c (0.76)	**3.35 a (0.73)**	3.12 b (0.74)	2.50 de (0.70)
A3	Frequency of pleasant experiences with the environment in the last week (*1: none, 2: 1–2 times, 3: 3–6 times, 4: every day*)	**2.24 a (0.95)**	1.75 cd (0.80)	1.63 de (0.70)	**1.59 e (0.76)**	1.98 b (0.95)	1.75 cd (0.79)	1.82 bc (0.87)
A4	Frequency of unpleasant experiences with the environment in the last week (*1: none, 2: 1–2 times, 3: 3–6 times, 4: every day*)	**2.28 a (0.92)**	1.94 b (0.86)	2.00 b (0.84)	**1.63 c (0.80)**	1.72 c (0.82)	1.72 c (0.74)	1.76 c (0.78)
A5	Number of familiar environmental terms in a list (*1 to 15 terms*)	**8.62 a (3.06)**	6.29 c (2.78)	7.82 b (3.25)	**5.17 d (2.60)**	5.38 d (3.10)	6.47 c (2.78)	5.62 d (2.69)
A6	Recognition of climate change issues (*1: never heard of, 2: heard of, 3: know to some degree, 4: know well*)	**2.93 a (0.54)**	2.76 bc (0.59)	2.88 a (0.48)	**2.39 e (0.66)**	2.67 cd (0.67)	2.84 ab (0.54)	2.58 d (0.63)
B1	Extent of interest in environmental problems (*1 [strongly uninterested] to 5 [strongly interested]*)	**4.06 a (0.63)**	3.43 d (0.78)	3.49 cd (0.68)	**2.78 e (0.79)**	3.60 bc (0.74)	3.64 b (0.66)	3.42 d (0.74)
B2	Pro-environmental attitude (New Environmental Paradigm) scale (*1 [anti-environmental] to 5 [pro-environmental]*)	**3.69 a (0.46)**	3.48 b (0.41)	3.76 a (0.36)	3.26 c (0.36)	3.31 c (0.36)	**3.17 d (0.31)**	3.27 c (0.35)
B3	Environmental protection can foster economic growth (*1 [strongly disagree] to 5 [strongly agree]*)	**3.93 a (0.72)**	3.73 b (0.64)	**2.84 d (0.74)**	3.31 c (0.75)	3.91 a (0.64)	3.64 b (0.61)	3.29 c (0.71)
B4	Environmental protection requires economic growth (*1 [strongly disagree] to 5 [strongly agree]*)	3.60 b (0.94)	3.66 b (0.80)	**2.62 e (0.74)**	3.37 c (0.77)	**3.99 a (0.74)**	3.63 b (0.64)	3.18 d (0.74)
B5	Economic growth is always harmful to the environment (*1 [strongly disagree] to 5 [strongly agree]*)	**2.84 d (0.90)**	3.34 b (0.86)	3.09 c (0.85)	3.11 c (0.79)	**3.58 a (0.90)**	3.34 b (0.74)	3.02 c (0.73)
C1	Number of environmental protection practices engaged in from a list (*1 to 8 practices*)	**4.95 a (1.55)**	3.15 c (1.36)	3.30 c (1.36)	**1.90 d (1.28)**	3.68 b (1.48)	3.13 c (1.48)	3.06 c (1.36)
C2	Intensity of environmental protection activity in comparison to that of friends and colleagues (*1 [much less] to 5 [much more*)	**3.79 a (0.66)**	3.13 cd (0.60)	3.06 d (0.55)	**2.56 e (0.71)**	3.28 b (0.65)	3.24 bc (0.63)	3.25 bc (0.58)
C3	Frankly speaking, I don't want to practice energy-saving or frugal behaviors (*1 [strongly disagree] to 5 [strongly agree]*)	**1.42 e (0.54)**	2.04 c (0.68)	2.13 c (0.67)	**3.07 a (0.80)**	1.66 d (0.60)	2.49 b (0.72)	2.11 c (0.80)
C4	I want convenience even though it is bad for the environment (*1 [strongly disagree] to 5 [strongly agree]*)	**1.56 e (0.58)**	2.26 c (0.71)	2.33 c (0.71)	**3.30 a (0.73)**	1.77 d (0.64)	2.59 b (0.71)	2.23 c (0.76)
C5	I prefer fast shipping and transportation even if it could be bad for the environment (*1 [strongly disagree] to 5 [strongly agree]*)	**1.84 d (0.78)**	2.47 c (0.77)	2.58 c (0.76)	**3.44 a (0.71)**	1.94 d (0.71)	2.84 b (0.70)	2.50 c (0.77)

Table 2. *Cont.*

	Questions and Responses	Environ-Mentalists	Dissat-Isfieds	Inacti-Vators	Bystan-Ders	Honeybee	Optimists	Moder-Ates
D1	Sufficiency of information on the environment (*1 [very insufficient] to 5 [very sufficient]*)	**2.99 a** **(0.75)**	2.60 c (0.73)	2.44 d (0.64)	**2.35 d** **(0.70)**	2.63 bc (0.78)	2.97 a (0.68)	2.74 b (0.65)
D2	Central government's environmental protection efforts (*1 [very insufficient] to 5 [very sufficient]*)	2.51 c (0.72)	**2.03 d** **(0.58)**	2.71 b (0.65)	2.61 bc (0.69)	**3.34 a** **(0.72)**	3.27 a (0.59)	2.61 bc (0.68)
D3	Local government's environmental protection efforts (*1 [very insufficient] to 5 [very sufficient]*)	2.61 b (0.71)	**2.05 c** **(0.59)**	2.66 b (0.65)	2.62 b (0.69)	**3.40 a** **(0.66)**	3.31 a (0.61)	2.62 b (0.62)
D4	Corporations' environmental protection efforts (*1 [very insufficient] to 5 [very sufficient]*)	2.09 c (0.72)	**1.82 d** **(0.62)**	2.02 c (0.64)	2.35 b (0.75)	2.99 a (0.84)	**3.03 a** **(0.72)**	2.33 b (0.71)
D5	NGOs' environmental protection efforts (*1 [very insufficient] to 5 [very sufficient]*)	3.29 c (0.71)	**2.56 e** **(0.72)**	3.49 b (0.64)	3.01 d (0.72)	**3.66 a** **(0.66)**	3.53 ab (0.60)	2.99 d (0.65)
D6	Citizens' environmental protection efforts (*1 [very insufficient] to 5 [very sufficient]*)	2.63 b (0.67)	**2.16 c** **(0.66)**	2.71 b (0.61)	2.69 b (0.69)	**3.28 a** **(0.74)**	3.23 a (0.60)	2.71 b (0.61)
E1	Influence of environmental status on quality of life (*1 [not at all influential to 5 [strongly influential]*)	4.16 a (0.66)	4.06 a (0.67)	3.85 b (0.69)	3.37 d (0.74)	**4.18 a** **(0.58)**	3.59 c (0.59)	**2.93 e** **(0.66)**
E2	Influence of economic factors on quality of life (*1 [not at all influential to 5 [strongly influential]*)	4.21 b (0.69)	4.28 ab (0.61)	**4.34 a** **(0.59)**	3.90 c (0.76)	4.38 a (0.58)	3.67 d (0.68)	**2.99 e** **(0.69)**
E3	Influence of societal factors on quality of life (*1 [not at all influential to 5 [strongly influential]*)	3.95 b (0.70)	**4.10 a** **(0.59)**	3.86 b (0.61)	3.62 c (0.67)	4.19 a (0.56)	3.52 c (0.60)	**2.86 d** **(0.55)**

Numbers in parentheses indicate standard deviation from the mean. Differences in scores among groups were significant for all response questions (one-way ANOVA; $p < 0.001$). Letters indicate significant differences among the groups (Scheffe post-hoc test; $p < 0.05$). The highest and lowest mean score for a response question are indicated in bold.

Figure 2 describes how the seven clusters were distinguished by the first two principal components. For example, the environmentalists were the highest (2.64) and the bystanders were the lowest (−2.36) in Comp. 1, which represents respondents' participation in environmental protection practices. On the other hand, honeybees were the highest (2.41) and the dissatisfieds were the lowest (−1.50) in Comp. 2, which represents positive evaluation of environmental protection efforts of government, corporates, and citizens. The inactivators and the moderates were aggregated around the center of the two components.

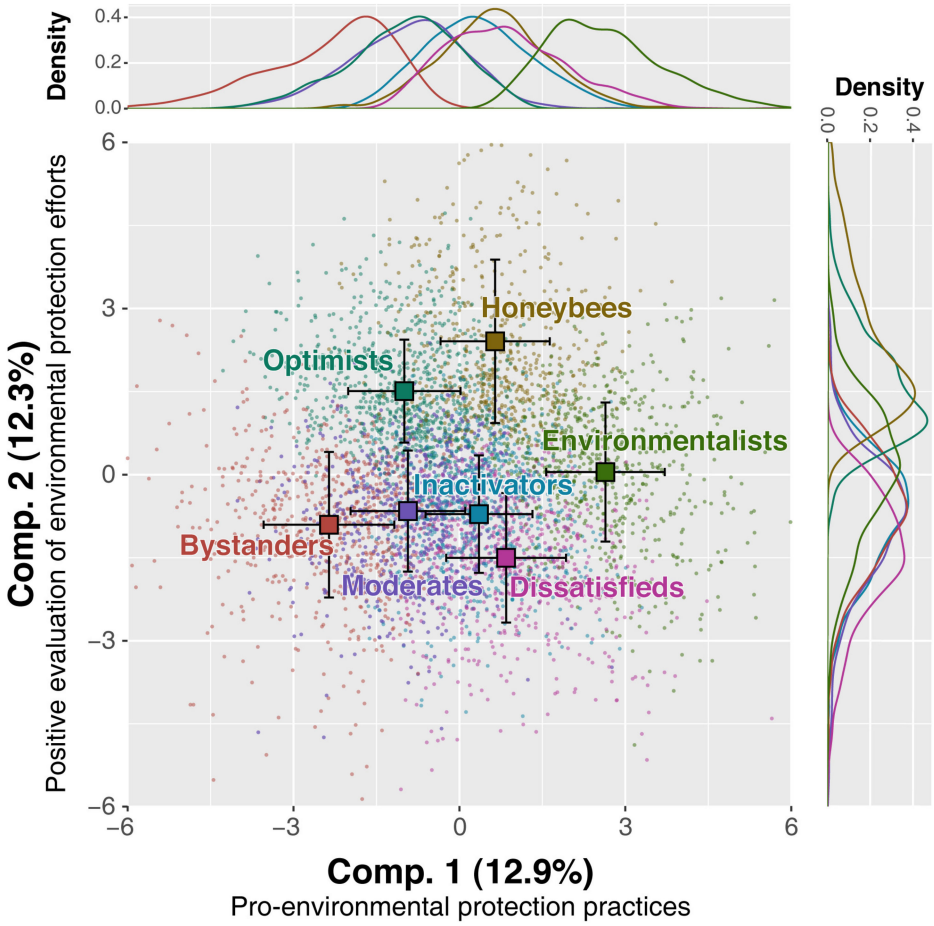

Figure 2. Score distribution of the first two principal components by clustered environmental awareness and attitude groups. Each rounded point represents each respondent's scores. Squared points and error bars indicate mean scores and standard deviations by the seven environmental awareness and attitude groups, respectively. The upper and right panels show the density distribution of the first and second principal component, respectively.

In addition, a Sankey diagram describes how the clusters diverged with an increase in the number of clusters from two to seven, and how analogous the seven clusters are at the lower level of divergence (i.e., smaller number of clusters) (Figure 3). For example, respondents who were categorized as honeybees or optimists at the level of the seven clusters, were mostly segmented to an ideal cluster; it indicated a close phylogenetic relationship between these two groups.

3.2. Key Features of the Seven Groups of Environmental Attitude and Awareness

The environmentalists were an aggregate of respondents who knew environmental terms the most (A5), who were interested in environmental problems the most (B1), who have the most pro-environmental attitude (B2), and who engage in environmental protection practices the most (C1).

Therefore, they were placed in the right side of Comp. 1, representing pro-environment practice of the PCA plot (Figure 2). In addition, their responses were highest for the following questions: frequency of pleasant experiences with the environment in the last week (A3), recognition of climate change issues (A6), intensity of environmental protection practice in comparison to that of friends and colleagues (C2), information sufficiency on the environment (D1), and influence of environmental status on the quality of life (E1). They agreed least with statements opposing the pro-environment attitude (C3–C5).

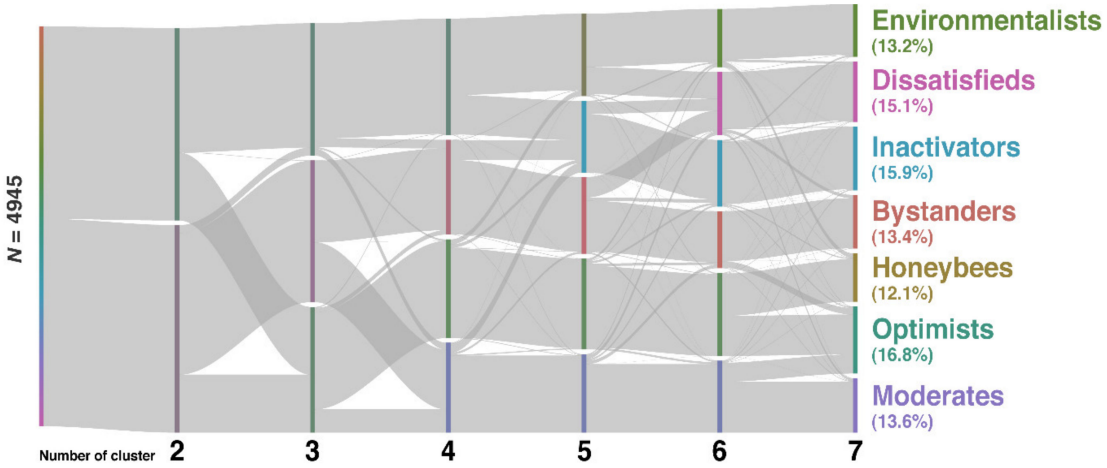

Figure 3. Divergence of segments on environmental awareness and attitudes with an increase in the number of *k*-means clusters from two to seven. Length of a bar and width of a flow represent relative number of respondents.

In another cluster, respondents were least satisfied with the status of the environment (A1) and the environmental protection efforts of all societal sectors, including central and local government, corporations, NGOs, and citizens (D2–D6). This group was named the dissatisfieds. They occupied the lower side of Comp. 2 (Figure 2). Their environmental perception, awareness, attitudes, and practices were of a moderate level (e.g., A5, A6, B2, and C1). Nearly half of the dissatisfieds were classified into an ideal cluster with environmentalists at the level of five clusters (Figure 3).

In contrast to the dissatisfieds, the optimists were positive about the status of the environment (A1, A2) and the environmental protection efforts of all societal sectors (D2–D6). Therefore, they were located at the upper side of Comp. 2, in contrast with the sphere of the dissatisfieds (Figure 2). They had the second highest score on the recognition of climate change issues (A6) and the extent of interest in environmental problems (B1) and the lowest score on the pro-environmental attitude (NEP) scale (B2).

The inactivators had pro-environmental perception and attitude like the environmentalists; on the other hand, their practices for environmental protection were not as high as their pro-environmental perception and attitude. They were the second highest group in the number of familiar environmental terms (A5) and the first highest group in the pro-environmental attitude (NEP) scale (B2). However, the inactivators were much lower in the number of environmental protection practices engaged in a list (C1) and intensity of environmental protection activity compared with friends and colleagues (C2) than the environmentalists. They responded with the second lowest score in the sufficiency of information on the environment (D1).

Respondents who were least interested in environmental problems and most unengaged with environmental protection practices were named bystanders. They had the lowest scores in frequency of pleasant and unpleasant experience with the environment in the last week (A2, A3), number of familiar environmental terms in a list (A5), recognition of climate change issues (A6), interest in environmental problems (B1), the NEP scale (B2), and engagement in environmental protection practices (C1, C2). The bystanders were scattered on the lower left side of the PCA plot (Figure 2), indicating that

they compared with the environmentalists or the honeybees in terms of pro-environmental practices (Comp. 1) or evaluation of societal sector's efforts for environmental protection (Comp. 2), respectively.

Honeybees are respondents who had the second least knowledge of environmental terms (A5) and awareness of climate change (A6), but the second highest engagement in environmental protection practices (C1) and agreement on barriers to practicing environmental-friendly activities (C3–C5). In addition, they had the most positive attitude to economic growth for environmental protection (B3–B5).

Finally, the remainders who were not classified into the other groups were aggregated in the moderates because most of their responses fell in the middle of the overall responses. They did not express clear preferences or opinions to the questions. Although their scores in some questions ranked the highest or lowest (E1–E3), this result may have been due to their preference for middle scores (i.e., 3 points on a 5-point Likert scale), whereas the others mostly gave one-sided responses.

3.3. Sociodemographic Characteristics of Each Group

Even though there was no dramatic segmentation in sociodemographic variables, such as age class, sex, education level, marital status, and household income by the seven groups of environmental awareness and attitudes, statistically significant differences were observed in all sociodemographic variables (Figure 4). Honeybees had the highest mean age (46.8) with the highest proportion of 60s (19.9%); whereas, the bystanders had the lowest mean age (40.7) with the highest proportion of 20s (29.6%). The bystanders had a significantly higher male proportion (61.0%) than others (44.5–51.5%). Mean score of education level (1: middle school, 2: high school, 3: undergraduate, 4: graduate) was significantly highest in the environmentalists (2.54) and the inactivators (2.54); however, the differences in education level by the groups (2.32–2.54) were minor. Proportion of married respondents was the highest in the environmentalists (83.9%) and the honeybees (82.9%) and the lowest in the bystanders (60.1%). Monthly household income was highest in the optimists (4.29 M KRW [South Korean Won]) and the inactivators (4.24 M KRW) and lowest in the honeybees (3.88 M KRW).

3.4. Differences in Literacy-Behavior Relationship and Preference to Environmental Protection Policy by the Groups of Awareness and Attitudes of the Environment

The clustering approach to awareness and attitudes toward the environment could reveal differences in literacy-behavior relationship by the groups of awareness and attitudes toward the environment (Figure 5). A significantly positive relationship between environmental literacy and behavior was observed among the inactivators, the bystanders, the honeybees, the optimists, and the moderates; in particular, that of the optimists ($R = 0.202$) and the honeybees ($R = 0.164$) was the most powerful. In contrast, environmental behavior was independent of literacy among the environmentalists and the dissatisfieds.

In addition, slightly different preferences for environmental protection policy were observed among the groups of awareness and attitudes toward the environment (Figure 6). Overall, respondents would most likely select "enhancing environmental information & education" (42.4%), followed by "enforcing regulations strictly" (37.7%), "increasing fines" (27.1%), "introducing stricter regulations" (25.6%), and so on. The honeybees (51.2%) and the optimists (46.3%) selected "enhancing environmental information & education" more than the others. The inactivators selected "enhancing environmental information & education" (34.6%) relatively less and "enforcing regulations strictly" (41.9%) relatively more than the others. The environmentalists were relatively less interested in "enforcing regulations strictly" (34.4%) and "increasing fines" (22.6%), but more interested in "efforts in individual entities" (25.2%) than the others.

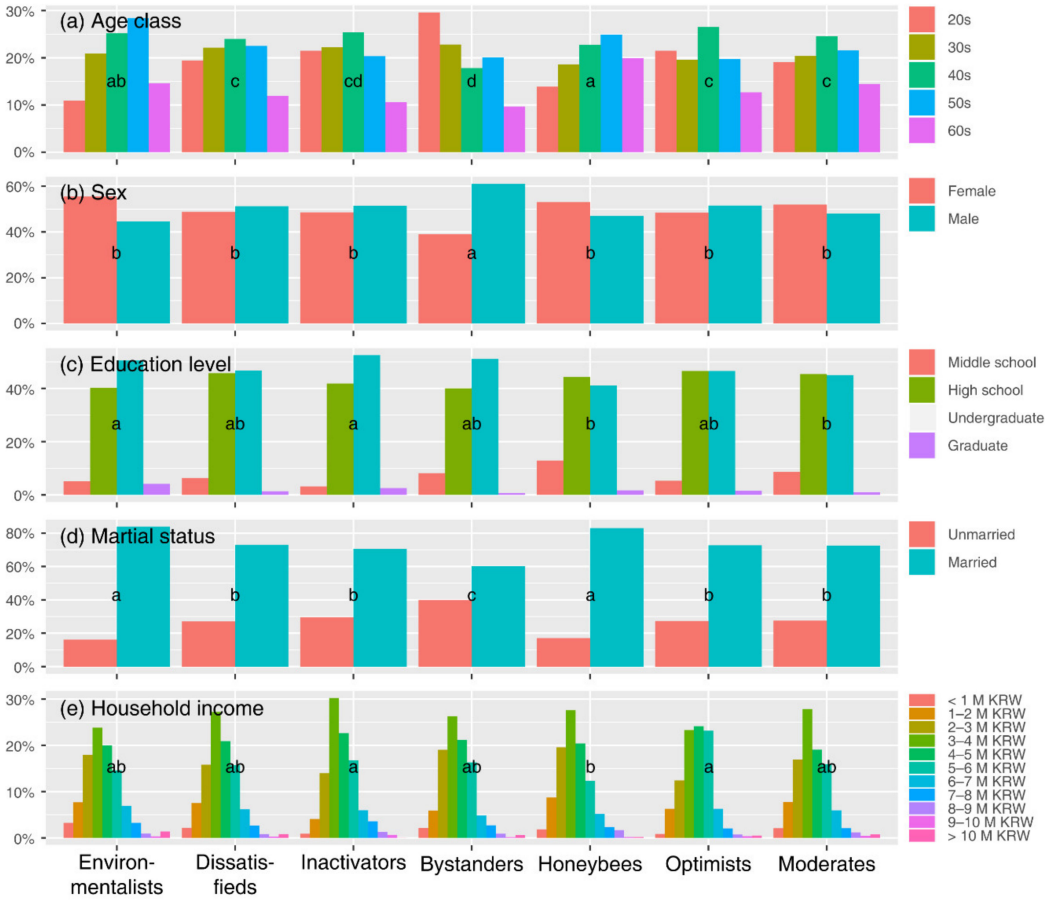

Figure 4. Sociodemographic distributions of respondents by seven groups of environmental awareness and attitudes. Letters indicate significant differences among the groups (Scheffe post-hoc test; $p < 0.05$). One million South Korean Won (KRW) is equivalent to USD 800–900.

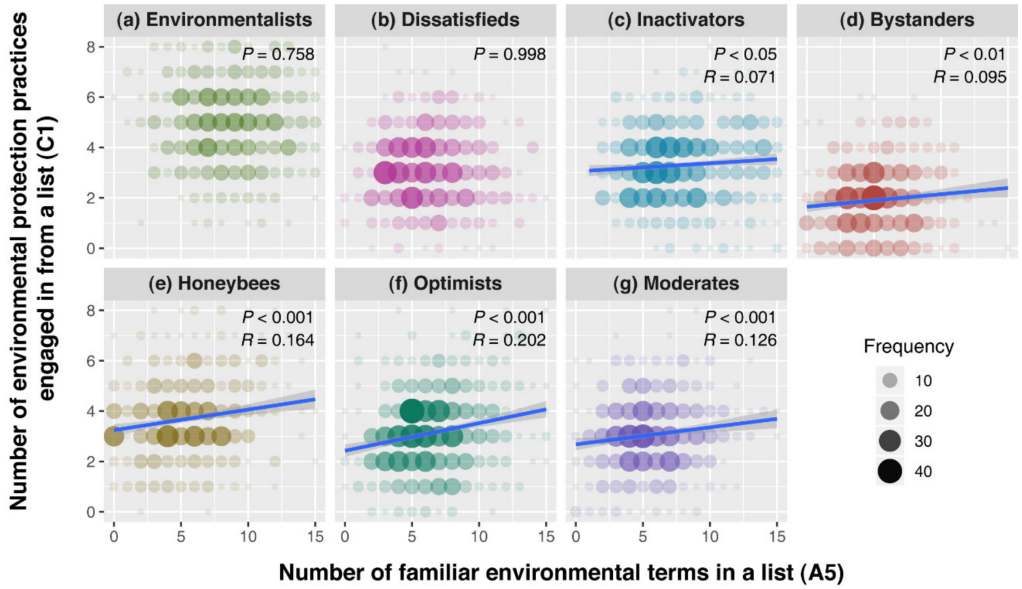

Figure 5. Relationship between environmental literacy and practices which were represented by a number of familiar environmental terms in a list (A5) and a number of environmental protection practices engaged in, from a list (C1), respectively, by the groups of environmental awareness and attitudes.

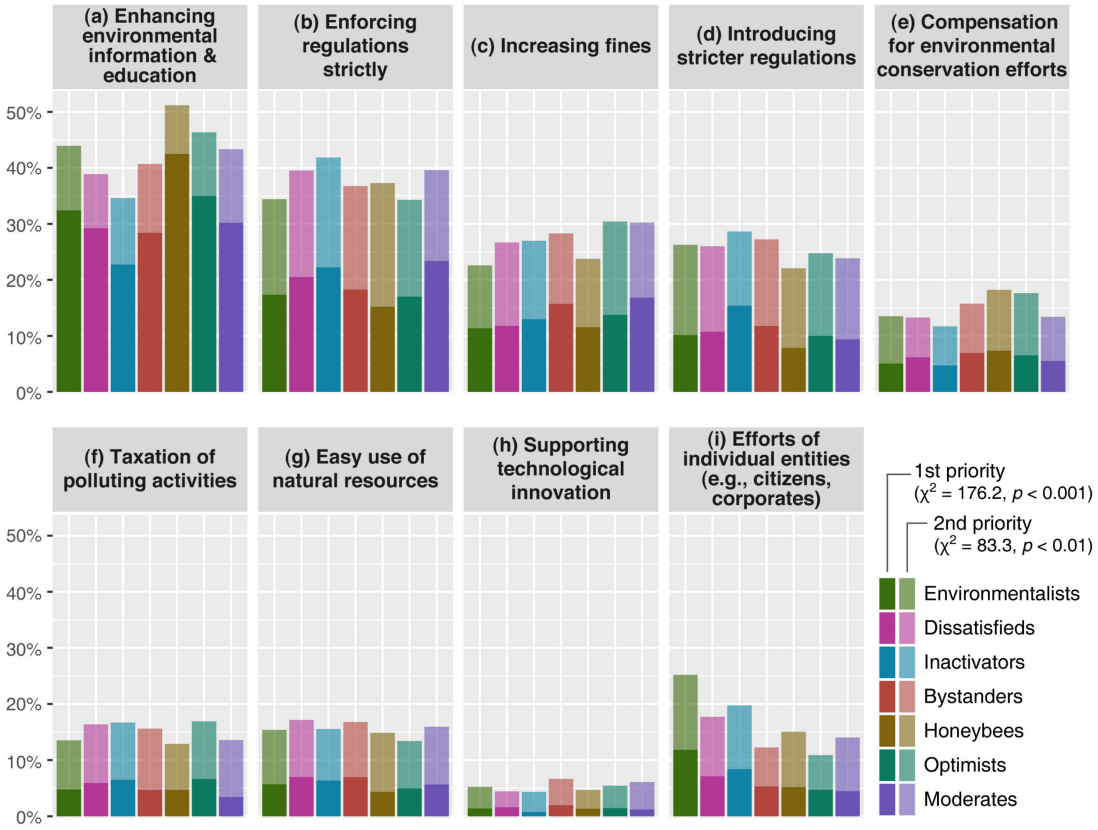

Figure 6. Effective means to protect environment on a list. Multiple answers were possible up to two.

4. Discussion

4.1. Landscape of Environmental Awareness and Attitudes

Cluster analysis could untangle the heterogeneous topography in the landscape of environmental awareness and attitudes of publics. The typology was primarily segregated by pro-environment practices (Comp.1; C1) distinguishing the environmentalists versus the bystanders and evaluation of environmental protection efforts on societal sectors (Comp. 2; D2–D4) distinguishing the honeybees and the optimists versus the dissatisfieds (Figure 2; Table A2).

The Sankey diagram revealed detailed phylogenic similarities and differences among the environmental awareness and attitudes. First, the environmentalists, the dissatisfieds, and the inactivators had a close phylogenic relationship, which is shown as the divergence of these groups after four-group clustering level (Figure 3). They had similar scores in environmental satisfaction (A1, A2) and pro-environmental attitude (B2); however, they differed in number of environmental protection practices (C1) and interest in environmental problems (B1) (the environmentalists versus the others) or environmental literacy (A5) and evaluation on environmental protection efforts of societal factors (D2–D6) (the dissatisfieds versus the others) (Table 2). In terms of perception, awareness, attitudes, and practices, the environmentalists may represent the ideal group of what is expected from a pro-environmental respondent. The dissatisfieds and the inactivators, on the other hand, have slightly different orientations. They are seriously concerned about the status of the environment and societal efforts to protect it, and express moderately pro-environmental awareness and attitudes, but do not make active effort to protect the environment themselves.

Second, the optimists and the honeybees shared a close phylogeny (Figure 3). They had no big differences in overall questions; for example, both were satisfied with the environment (A1) and concerned about the environment as a problem (B1). However, the optimists had somewhat higher

scores in environmental literacy (A5) and lower scores in environmental protection practices (C1) than the honeybees (Table 2). The honeybees demonstrated a low level of environmental awareness and attitudes (A5, A6, B2); however, they engaged actively in environmental protection practices (C1). Moreover, the honeybees were characterized by the oldest, the least educated, and belonged to the least income-based sociodemographic group (Figure 4).

Third, mainstreams of the bystanders and the moderates were diverged after the three-group clustering level (Figure 3), indicating another close phylogenic relationship. As their responses were plotted on the lower left side of the PCA plot in Figure 2, they had similarities except considerable differences in interest in environmental problems (B1) and environmental protection practices (C1). in which the bystanders had the lowest scores. Therefore, the moderates can be interpreted as a group which had environmental awareness and attitudes as weak as the bystanders, but interest and behaviors toward the environment not as low as the bystanders.

4.2. Segmentation by Generation

Generation could regulate people's environmental awareness and attitudes in addition to the pro-environmental factors. While older respondents were segmented more into the honeybees, younger respondents were more into bystanders. This may be unsurprising to Koreans because recent public opinion on various social issues has been split by generation, occasionally overwhelming other sociodemographic factors such as region, income and class, and religion [36].

According to a review by Gifford and Nilsson [37] on personal and social factors of environmental concerns and behaviors, age could have an effect through three mechanisms: cohort effect, aging effect, and era effect. The cohort effect emphasizes the presence or absence of specific events or experiences affecting a certain generation's environmental concerns and behaviors, whereas the aging and era effects assume that people become more conservative and less interested in the environment with age.

The cohort effect could explain the divergence of values and behaviors by generation in Korea, acknowledging the country's dramatic social changes, such as economic development from the 1970s to 1980s and democratization from the 1980s to 1990s. Therefore, generation could be a proxy encompassing experiences not only of historical events but also of environmental circumstances, which are shared within each generation and diverged across generations.

The older generation, representing the developing period, are likely to have experienced poverty and frugality. Specifically, they might not be sufficiently educated about the environment; nevertheless, they engage in environmental practices, probably based on frugality rather than pro-environmental awareness and attitudes. Because environmental behaviors practiced by individuals relate mainly to a nonconsumptive lifestyle, such as reducing use of energy, water, and disposable items, frugality could be a strong motive for pro-environmental behaviors [38]. This environmental group was therefore named the honeybees, a symbol of industriousness, because honeybees unintentionally provide benefit to ecosystems and human well-being through pollination, which they engage in to satisfy their needs for honey, not because of an altruistic motive [39].

On the contrary, the younger generation, representing the post-development and post-democratization period, are less concerned about the environment. People raised in wealthy and consumptive circumstances may have weak motivation to engage in frugal actions, and therefore in environmental behaviors. In addition, single individuals in their 20s, the dominant group of the bystanders, engage in household affairs much less (70 min/day) than other ages (140–205 min/day), according to a time use survey conducted in Korea [40], resulting in limited opportunity to engage in environmental practices at the individual or household level.

4.3. Policy Application of Clustering Environmental Awareness and Attitudes

Cluster analysis is an inductive, heuristic, and exploratory approach to detect patterns in existing data without an ex-ante hypothesis. In other words, clustering relies entirely on what kind of information is contained in the survey data. AP-NORC [2] clustered Americans' environmental awareness and

attitudes into nine groups, probably defined by a combination of three dimensions: pro-environmental, outdoor activities, and Christian beliefs. However, the clustering pattern in this study was unlike the American case. Koreans' environmental awareness and attitudes could not be classified by religious attitudes or outdoor engagement, not because these factors are insignificant to Koreans, but because they were not surveyed in the PSAAE. Therefore, the seven groups suggested in this study are neither universal, constant, generalized, nor replicable classifications of the Korean public's environmental awareness and attitudes. If survey questions change, segmentation of environmental awareness and attitudes will change as well. The typology of Koreans' environmental awareness and attitudes obtained by cluster analysis is case- and survey-specific. In addition, the proportion of respondents clustered in each group is not greatly informative or comparable. For example, it cannot be said that 13.2% of Koreans are environmentalists (Figure 3), because the respondents who would be identified as environmentalists are variable depending on clustering method and predefined number of clusters.

Nevertheless, this cluster analysis could present a nice practice in identifying the heterogeneous interests and concerns of Koreans regarding the environment. The PSAAE is designed to cover a wide range of aspects, topics, and issues in environmental awareness and attitudes with an abundant number of questions and respondents. This ensures that the typology of environmental awareness and attitudes obtained by cluster analysis can come close to reliable constructed types (i.e., empirical types), which are determined by empirical, inductive methods in contrast to the conceptual, qualitative method of Weberian ideal types [19,41], and which reveal a portion of the reality of Koreans' environmental awareness and attitudes.

Here, the different patterns among the groups of awareness and attitudes of the environment in Figures 5 and 6 can be aligned with the debates on relationship between environmental knowledge and behavior, which were theoretically and empirically studied in previous studies [42–45]. Effects of knowledge, information, and/or learning on environmental behavior have been reported neither linear, apparent, nor simple-straight. Rather, personal attitude [44] or emotion [42] could play a role in mediating the pathway from knowledge to behavior. Frick et al. [43] and Jensen [45] took note of types of knowledge which distinguish action- and effect-related knowledge toward behavior against system-related or traditional knowledge. The complicated nature of knowledge-behavior relationship could result in discrepancies and gaps between them. Here, this study suggests that enhancing environmental literacy of publics could be effective or ineffective in promoting pro-environmental behavior depending on group of environmental awareness and attitudes. Information-driven behavioral change can be applied to the optimists and the honeybees well, as they gave a higher priority to "enhancing environmental information & education" for effective means to protect environment. However, the information-driven approach may not be functional to other groups, such as the environmentalists, the inactivators, and the dissatisfieds wherein environmental literacy-behavior relationship was weak or absent. Even though investigating relationship between knowledge and behavior is not within the primary scope of this study, it is presented to explore an application of clustering approach for designing customer-targeted strategy in environmental policy.

Therefore, the key contribution of clustering results is to provide an understanding of the complex landscape of environmental awareness and attitudes, beyond a simple, straightforward pro-environmental orientation. In particular, the seven groups were shaped by respective combinations of knowledge, attitudes, satisfaction, and environment-related behaviors. Although the environmentalist group was consistent with all aspects of pro-environmental awareness and attitude, the other groups were partially incongruous with these components. For example, the honeybees were strong in pro-environmental practices and weak in environmental knowledge, and the dissatisfieds did not engage in environmental behaviors, but had strong concerns about the environment. Therefore, this study successfully overcomes the problem of simplification, which fails to uncover the public's diverse thoughts on the environment and results in limited application using public environmental survey data.

These findings could illuminate the motives for and barriers to being pro-environmental for each group, identify target groups for environmental policy, and suggest customized policy and message needs to promote motives and deconstruct barriers. The information-driven approach in environmental policy must be the most effective for the honeybees who had weak environmental literacy but strong relationship between literacy and practice. Moreover, the bystanders are probably attracted by information regarding the money saving effects of institutional interventions and individual practices. The information-driven approach is also effective for the optimists who have the strongest relationship between literacy and practice. However, the messages should pay attention to the unique orientation of the optimists, which is slightly different from that of the honeybees; positive and hopeful policy messages rather than negative and concerned ones may be recommended for the optimists. On the contrary, the information-driven approach is not expected to be effective for the dissatisfieds with literacy-practice mismatch. The most effective method to satisfy the dissatisfieds would be enhancing environmental quality in terms of objective and perceived levels. Environmental policy to the dissatisfieds should target not only achievement of outcomes to reduction of pollutant emissions but also the message that informs them of environmental quality. Policy targets must be quite challenging for the inactivators and the bystanders unless the catalysts are identified that would activate the inactivators in terms of environmental practices or attract the bystanders' concerns. The public survey program and cluster analyses could discover the patterns of each group's awareness and attitudes toward the environment; further, qualitative analyses could reason the in-depth perception of each group beneath the uncovered patterns.

Here, the following questions are suggested to enhance understanding of the landscape of environmental awareness and attitudes and to develop environmental policy and message customized to heterogeneous interests and concerns of publics: Why are the optimists positive about the status of the environment and societal efforts to protect it? Why are the bystanders not concerned about the environment? What kinds of environmental practices are feasible for the bystanders, who are not highly involved in household affairs? Are there any environmental issues that the moderates can take interest in? Is the motive for the honeybees' environmental behaviors really frugality, as speculated in this study, rather than concerns about the environment? Why do the dissatisfieds not make any efforts to protect the environment in line with their strong concerns? Is the information-driven approach effective in activating the inactivators in terms of environmental protection practices?

5. Conclusions

Seven groups of environmental awareness and attitudes among Koreans—the environmentalists, the dissatisfieds, the optimists, the honeybees, the bystanders, the inactivators, and the moderates—were identified using cluster analysis. This study reveals various associations between knowledge, attitudes, concerns, satisfaction, and environmental behaviors, and consequently, can overcome simplified understanding such as one-dimensional of whether people are pro-environmental or not, or descriptive statistics by sociodemographic groups. Heterogeneous thoughts shape public opinion toward the environment; thus, policy designers and decision makers are asked to be aware of who their clients actually are.

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Appendix A

Table A1. Sociodemographic characteristics of the respondents from the public survey on awareness and attitudes toward the environment in South Korea from 2013 to 2017 (n = 5003).

Characteristics	Category	Respondents	Percentage (%)
Age class	20s	981	19.6
	30s	1046	20.9
	40s	1199	24.0
	50s	1114	22.3
	60s	663	13.3
Sex	Female	2460	49.2
	Male	2543	50.8
Education level	Middle school	347	6.9
	High school	2176	43.5
	Undergraduate	2387	47.7
	Graduate	93	1.9
Marital status	Unmarried	1331	26.6
	Married	3671	73.4
	Unanswered	1	0.0
Household income	< 1 M KRW	94	1.9
	1–2 M KRW	340	6.8
	2–3 M KRW	815	16.3
	3–4 M KRW	1329	26.6
	4–5 M KRW	1060	21.2
	5–6 M KRW	832	16.6
	6–7 M KRW	293	5.9
	7–8 M KRW	134	2.7
	8–9 M KRW	52	1.0
	9–10 M KRW	17	0.3
	>10 M KRW	29	0.6
	Unanswered	8	0.2
Size of residential area	Small town	418	8.4
	Intermediate city	2108	43.6
	Metropolitan city	2405	48.1

Table A2. Mean scores of eight principal components by clustered environmental awareness and attitude groups.

Principal Components	Environ-Mentalists	Dissat-Isfieds	Inacti-Vators	Bystanders	Honeybees	Optimists	Moderates
Comp. 1	**2.64 a (1.07)**	0.84 b (1.08)	0.35 c (0.97)	**−2.36 e (1.18)**	0.65 b (0.99)	−1.00 d(1.02)	−0.93 d (1.04)
Comp. 2	0.05 c (1.26)	**−1.50 f (1.17)**	−0.71 de (1.06)	−0.90 e (1.31)	**2.41 a (1.48)**	1.51 b (0.93)	−0.66 d (1.09)
Comp. 3	−0.52 e (1.21)	0.69 ab (1.03)	0.43 c (0.98)	**0.88 a (1.10)**	0.61 bc (1.03)	−0.28 d (1.02)	**−1.83 f (0.93)**
Comp. 4	−0.12 d (1.10)	**0.96 a (1.01)**	**−1.29 e (0.95)**	0.16 c (1.03)	0.58 b (0.98)	−0.30 d (0.88)	0.26 c (1.15)
Comp. 5	−0.20 d (1.08)	−0.29 d (1.16)	**0.78 a (1.04)**	−0.12 d (1.14)	0.41 b (1.06)	**−0.65 e (1.01)**	0.17 c (1.18)
Comp. 6	0.00 b (1.20)	−0.12 b (1.19)	**0.24 a (1.07)**	−0.02 b (1.14)	−0.04 b (1.17)	0.04 ab (1.08)	−0.14 b (1.09)
Comp. 7	**−0.33 d (1.10)**	**0.24 a (1.03)**	0.20 a (0.97)	−0.20 cd (1.04)	−0.10 c (1.22)	0.12 ab (0.98)	−0.05 bc (1.02)
Comp. 8	**0.37 a (1.15)**	−0.10 cd (1.02)	−0.23 d (0.98)	0.15 b (0.92)	**−0.24 d (1.05)**	0.04 bc (0.86)	0.04 bc (0.88)

Numbers in parentheses indicate standard deviation from the mean. Differences in scores among groups were significant for all response questions (one-way ANOVA; p <0.001). Letters indicate significant differences among the groups (Scheffe post-hoc test; $p < 0.05$). Highest and lowest mean score for a response question are indicated in bold.

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