

Taiwanese Public Awareness and Attitudes about Global Warming and Intentions to Participate in Planting Trees for Carbon Sequestration

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【 Summary 】

As planting trees is one of the feasible strategies for reducing greenhouse gases, this study conducted a mail questionnaire survey on the topics of global warming and planting trees, in which respondents were the general public in Taiwan. Based on this survey, we determined and analyzed the general public's feelings, attitudes, and awareness about some environmental and ecological problems, such as global warming and climate change, and further investigated the extent to which they might participate in planting tree for carbon sequestration. Our results showed that respondents were most concerned about global warming among environmental and ecological problems, and also thought that global warming was the most serious problem. By a one-way ANOVA, it was found that significant differences existed in the level of respondents' concern about global warming based on their age and educational level. By a factor analysis, 2 common factors of 'improved action of global warming' and 'awareness of and concern about global warming' were extracted from the 'improved action of global warming' dimension, where the highest level of education and occupation showed significant differences. The percentage of respondents who considered or had been engaged in tree-planting activities to reduce carbon accounted for 81.4% of the total. Among 5 suggested programs for planting trees, the ratio of planting trees in a personal garden or on one's balcony was the highest, which accounted for 79.0%. On the impetus for policies, this study discovered that if the public understood the contents of policies more clearly, then their intention to participate in planting trees would also rise. As a consequence, it is suggested to enhance persuasion and guidance of the public to participate in planting trees to reduce carbon, so as to increase their understanding of related information about planting trees, and also to achieve effective communication.

Key words: global warming, climate change, carbon sequestration, planting trees, afforestation intention.

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研究報告

民眾對全球暖化知覺、態度與植林減碳意願之研究

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摘要

植樹造林為溫室氣體減量的可行策略之一，本研究以臺灣民眾為對象進行郵寄問卷調查，以瞭解民眾對包含全球暖化的知覺與態度，進一步探究對植林減碳的參與意願。結果發現：受訪者對「全球暖化」的關心程度最高，也認為「全球暖化」為最嚴重的環境與生態問題。應用單因子變異數分析結果，受訪者對全球暖化的關心程度在年齡及學歷上有顯著差異，所認知的嚴重程度上，則受訪者學歷及職業上有顯著差異。藉由因素分析，共萃取出「全球暖化的改善行動」及「全球暖化的認知與關注」二個共同因素，在「全球暖化的改善行動」因素構面結果，則在最高學歷及職業上有顯著的差異。受訪者考慮或已從事植樹造林來達成減碳的目的者占81.4%，其主要採取的參與方式，在所列出5種可能方式中，以在自家庭園或陽台植樹的比例最高占79.0%。本研究發現對政策的推動，如民眾知道其內容，其參與意願也會提高，建議應加強對植林減碳的宣導，以增加民眾對相關知識的瞭解，達成有效溝通。

關鍵詞：全球暖化、氣候變化、減碳、造林、植林意願。

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INTRODUCTION

Global warming and climate change are recognized as unprecedented challenges by most countries worldwide. Climate change has already caused a great deal of serious damage, and if humans do not pay more attention to environmental protection, the greenhouse effect will become even more serious. According to the Intergovernmental Panel on Climate Change (IPCC), the Fourth Assessment Report estimated that by the end of this century, the average global temperature will have risen by 6.3°C, while the sea level was predicted to rise by 58 cm. If the average global temperature increases by 4°C, about 3 billion people will face a water-shortage crisis, and more aquatic creatures will become extinct. Another fact attesting to the seriousness of global warming is that

the average global temperature increased by 0.74 (0.56~0.92)°C from 1906 to 2005, which is higher than the estimated average global temperature rise from 1901 to 2000 in the IPCC Third Assessment Report (published in 2001) of an increase of 0.6 (0.4~0.8)°C (IPCC 2007).

During the past 2 decades, almost every country in the world has expressed concern about climate change and global-warming issues (Thompson and Rayner 1998, DEFRA 2002, Poortinga and Pidgeon 2003, OST and MORI 2004). According to Dunlap and Scarce (1991), only 12% of respondents thought global warming was very serious in 1982, while 36% did not know about the greenhouse effect. In 1988, for the same question, 39% of respondents thought that

global warming was very serious, while only 15% did not know about the greenhouse effect. By surveying the general public from 24 different countries, Dunlap (1994) found that the public in 13 countries thought global warming was very serious in 1992. Bord et al. (2000) conducted a survey of the level of understanding about knowledge of climate change of the public in 15 different European countries, for which only 53% of respondents had a good understanding or knowledge of climate change. GlobeScan (2000) investigated the public in 34 different countries and found that respondents from most countries thought that global warming was a serious environmental problem, but compared to other environmental problems, global warming was ranked only seventh among 8 environmental problems. Leiserowitz (2003) surveyed students at the Univ. of Oregon (USA), among which 92% of respondents had heard about global warming, and 74% of respondents were concerned about it. Norton and Leaman (2004) surveyed the public in the UK who were older than 16 yr on their opinions about global warming, and found that almost everyone had heard about global warming, but only 67% of respondents understood issues related to it. Although climate change and global-warming problems have received increasing amounts of attention, they were previously not the public's major concern in terms of environmental problems. For example, some previous surveys indicated that the public paid less attention to global warming than to other environmental problems, such as water and air pollution (Bostrom et al. 1994, Kempton et al. 1995, DEFRA 2002, Hinds et al. 2002, Poortinga and Pidgeon 2003, Bibbings 2004, The Polling Report 2004, Leiserowitz 2007). Curry et al. (2004) surveyed Americans about the level of their concern on 17 different environmentally related issues, and

found that water-pollution problems received the most attention, while global warming was ranked 6 among all environment-related issues. Leiserowitz (2004) had a similar result in which global warming was ranked fifth among 9 environmental issues.

Increasing scientific evidence has confirmed the existence of climate change and global warming, and the resultant environment changes have already greatly impacted our lives. As humans increasingly experience the seriousness of global warming, they are paying increasing attention to environmental issues caused by global warming (Leiserowitz 2007). In a survey conducted by the Swedish Environmental Protection Agency, the ratio of Swedish respondents who had heard about climate change in 2008 was 97%, which was more than that in the 2002 survey results (89%). And the ratio of those who thought that the situation with climate change was becoming more serious increased from 63% in 2002 to 71% in 2008 (Swedish Environmental Protection Agency 2008). That study also analyzed the EU public's attitudes on climate change, and found that global warming/climate change (62%) was considered the second most serious environmental problem in the world, which followed poverty and a lack of food and drinking water (68%). Compared to the previous survey, the seriousness level of global warming/climate change had increased (EU 2008). Sampei and Aoyagi-Usui (2009) compared the Japanese public's awareness of environmental issues in 1997, 2002, 2006, and 2007, and found that the public's awareness of environmental issues had gradually focused on global-warming issues. Curry et al. (2005) found that the environmental issue of most concern to UK people was global warming (49%). In 2006, the public in 10 different countries was surveyed, and most of the respondents felt

threatened by environmental problems associated with climate change in the next decade (Chicago Council on Global Affairs 2007). The EU analyzed the EU public's attitudes about climate change in 2008, and found that people in almost all of the countries thought global warming or climate change was a serious problem. Among 27 countries, respondents from 12 countries thought global warming or climate change was the most serious problem, while respondents from 13 countries thought poverty and a lack of food and drinking water was the most serious problem (EU 2008). GlobeScan (2000 and 2006) surveyed levels of the public's concerns in 34 different countries about the severity of the greenhouse effect due to global warming and climate change in 2000 and 2006, respectively. The survey results showed that the ratio of respondents who thought the problem of climate change was increasingly serious significantly increased. In Taiwan, a survey conducted by *Vision Magazine* in 2007 showed that 88.5% of respondents considered global warming to be a serious problem (Vision Magazine 2007).

In light of the above, the seriousness of global warming has received a lot of attention in most countries of the world, and therefore, determining how to reduce the impacts of global warming and slow down the crisis due to climate change has been actively explored in each country in recent years. In general, there are 2 strategies to reduce greenhouse gases: reduce the emissions of greenhouse gases and increase the absorption of greenhouse gases. With the absorption strategy, photosynthesis by plants and trees is used to absorb and fix CO₂ from the atmosphere. On the other hand, deforestation is the main source of CO₂ emissions. Therefore, changes in forestlands are playing key roles in the carbon cycle of the earth. When a tree is in the growth stage, carbon dioxide is seques-

trated. When a tree is harvested, a part of the sequestered carbon returns to the atmosphere, but most of the carbon is still stored and fixed in another form, i.e., wood products. In the carbon cycle, CO₂ does not disappear, but is just temporarily stored in forests and wood products. Through planting trees and forest management (e.g., see Niu and Duiker 2006), the absorption and storage of CO₂ can be incremented. Forests will play a key role in international climate change negotiations at the United Nations after 2012. Now, energy savings and carbon reduction are major policies of the Taiwanese government, while the Council of Agriculture (COA) in Taiwan also lists energy savings and carbon reduction as one of 10 key industrial research teams, and promotes planting trees by target-based projects.

In light of the above information, it is clear that public opinion can affect political, economic, and social actions, which can effectively reduce specific risks (Leiserowitz 2007), and for the global-warming issue, the public's awareness and attitudes are a major key to solving climate change, global warming, and other environmental issues¹⁾. However, differences in the public's personal characteristics and levels of their awareness about related knowledge can lead to differences in attitudes and behaviors toward global warming and other environmental problems. Therefore, understanding public opinion should help governments develop and promote effective policies; e.g., Chang et al. (2009) conducted a mail survey on forest pest outbreaks and control to help policy makers and forest managers arrive at publicly acceptable pest-control policies and make better-informed decisions. The success and failure of a policy may depend on the public's awareness and attitudes toward that policy. Since planting trees is one of the feasible strategies for carbon reduction, it is necessary to understand

the public's attitudes toward planting trees for carbon reduction, so as to ensure that policies are successful. For this reason, we conducted a mail survey to understand the Taiwanese public's feelings on global warming and other environmental issues, analyzed their attitudes and awareness about global warming, and further explored their participation in planting trees for carbon reduction, to provide a reference for promoting relevant policies.

MATERIAL AND METHODS

Design of the questionnaire

Our questionnaire was designed by referring to previous studies. The questionnaire consisted of 4 parts. In the first part, to understand the respondents' awareness of environmental and ecological problems, they were asked the level of their concern and levels of their awareness about the seriousness of 13 various environmental and ecological problems, using a 7-point Likert scale from 1 (not at all concerned or not severe) to 7 (greatly concerned or highly severe). In the second part, levels of the respondents' attitudes toward global warming were also measured on a 7-point scale, in which 20 questions on global warming were asked. In the third part, respondents were asked about their socioeconomic characteristics, including gender, age, educational level, marital status, occupation, personal monthly income, place of residence, and whether they had ever participated in environmental or religious groups or activities. In the fourth part, we measured the respondents' attitudes toward planting trees as a carbon sequestration policy, including whether they were aware that the government was promoting energy-saving and carbon-reduction programs, whether they had ever heard of a carbon-neutral or low-carbon lifestyle, and whether they had considered or

had been engaged in planting trees for carbon sequestration.

Since Heffernan (2006) indicated that the goal of testing content validity can be achieved by using expert validity, this study applied expert validity to evaluate the content validity. To ensure that the questionnaire was clear and easy to answer²⁾, it was pre-tested by 5 experts with different socioeconomic characteristics and the public, and the feasibility of the questionnaire was discussed³⁾.

After incomplete statements were revised and several questions were deleted, our formal questionnaire was finalized.

Survey methodology and sampling

This study conducted a questionnaire survey by mail and adopted a stratified systematic sampling method. The sample source was based upon the Household Registration and Conscription Information link data from the Ministry of Interior in 2009. The proportion of the population distributed in each county in Taiwan was used to choose people aged 15 yr or older in Taiwan as our sample. The sample size was 2000. The distribution of samples was based upon the proportion of the population in each county in Taiwan, not the proportion of each village and town. This survey was first carried out in July 2009, and then a request was sent by mail to those who had not yet replied in September. The deadline for the questionnaire survey was the end of October 2009. In total, 333 people completed the questionnaires, resulting in an effective questionnaire return rate of 16.7%⁴⁾.

Questionnaire analysis method

The questionnaire results were analyzed using the SPSS statistical software (Chicago, IL, USA) for data entry and analysis. First, descriptive statistics were used to analyze the questions and parameters, including the

level of respondents' concerns and the level of their awareness of the seriousness of environmental and ecological problems, the mean and standard deviation of their attitudes about global-warming issues, their socioeconomic characteristics, and their attitudes toward planting trees for carbon sequestration.

Furthermore, by a factor analysis, we extracted the factor dimensions from the respondents' attitudes toward global-warming problems. Before the factor analysis, the results of Bartlett's test of sphericity and the Kaiser-Meyer-Olkin (KMO) test were used to analyze whether the selected items were suitable for the factor analysis. Since the results of Bartlett's test of sphericity were significant and KMO values were > 0.8 , our survey was suitable for a factor analysis. After identifying suitable items, principal component factors were used to select common factors that were > 1 , and then Varimax was used to extract common factors among the orthogonal axis factors with a factor loading of > 0.4 as the selection criteria items. We also conducted a reliability analysis on the factor dimensions of the items, and used Cronbach's α coefficient to test the level of internal consistency of the factor dimensions of the items. An analysis of variance (ANOVA) was used to determine whether respondents with different socioeconomic characteristics had significant differences in the levels of their concern about the seriousness of global-warming problems, and extracted factor dimensions of their attitudes about global-warming issues, and whether respondents' willingness to participate in planting trees for carbon sequestration showed significant differences from the extracted dimensions of their attitudes toward global-warming issues. If the results indicated significant differences, then Duncan's multiple-range test was used to further explain the differences.

RESULTS AND DISCUSSION

Socioeconomic characteristics of respondents

The socioeconomic characteristics of respondents are shown in Table 1, in which the proportions of male and female respondents were similar (48.5% and 51.5% of all respondents); the highest proportion was of the age 26~35 yr (which accounted for 27.6% of all respondents), followed by 36~45 yr at 21.3% and those aged > 55 yr at 20.2%. Respondents who were married, unmarried, and had divorced accounted for 66.1, 29.9, and 4.0%, respectively. Respondents who had graduated from university (college) accounted for 55.3%, followed by these with a senior high school education at 20.4% of all respondents. As to the respondents' occupations, those engaged in commercial activities occupied a maximum of 22.6%, followed by the military and civil servants/teachers, at about 15.0% each. As to the personal monthly income of respondents, the answer "no income" occupied the highest percentage, accounting for 23.6%, the possible reason for which was that they were students or housekeepers, followed by those with NT\$20,000~30,000/mo, which accounted for 20.0%. From the cumulative percentage, more than one-half of respondents had personal monthly income of \leq NT\$30,000. Those with a personal monthly income of NT\$80,000 accounted for 5.6% (at the time of the survey, the exchange rate was US\$1.00 \approx NT\$30.13). A large proportion had never participated in any environmental or religious groups (82.7%), while only 17.3% of respondents answered that they had⁵⁾.

Respondents' awareness of environmental and ecological problems

Among 13 environmental and ecological problems, global warming, water pollution,

Table 1. Socioeconomic characteristic of respondents

Item	Percentage (%)
Gender	
Male	48.5
Female	51.5
Age (yr)	
15~25	12.6
26~35	27.6
36~45	21.3
46~55	18.3
> 55	20.2
Marital status	
Unmarried	29.9
Married	66.1
Divorced	4.0
Educational level	
Less than senior high school	9.9
Senior high school	20.4
University (college)	55.3
Graduate school and above	14.4
Occupation	
Military, civil servant, or teacher	15.0
Businessperson	22.6
Laborer	13.1
Student	6.4
Self-employed	7.3
Housekeeper	11.3
Retired	8.6
Unemployed	4.9
Other	10.7
Personal monthly income (NT\$)*	
None	23.6
< 20,000	9.4
20,000~30,000	20.0
30,000~40,000	14.2
40,000~50,000	10.9
50,000~60,000	8.5
60,000~70,000	4.2
70,000~80,000	3.6
> 80,000	5.6
Place of residence	
Northern	48.2
Central	23.2
Southern	21.7
Eastern	6.9

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Involved in any environmental or religious groups?

No	82.7
Yes	17.3

* At this time of the survey (2011), the exchange rate was US\$1.00 \approx NT\$30.

air pollution, climate anomalies, and inappropriate human development were the environmental and ecological problems of greatest concern, with respective means of 6.20, 6.09, 6.07, 6.02, and 5.88. Also, the above 5 problems were more serious problems, but the rank slightly differed, with global warming still the most serious problem (with a mean of 6.31), followed by inappropriate human development (6.09), air pollution (6.08), water pollution (6.07), and climate anomalies (6.06), which showed that the awareness of the seriousness of these 4 environmental and ecological problems exhibited small differences (Table 2). Comparing the ranks of the level of the respondents' concerns and their level of awareness about the seriousness of environmental and ecological problems, inappropriate human development issues ranked fifth of 13, but the awareness level ranked second of 13. From the higher levels of respondents' concerns and awareness about global warming, it is evident that respondents were aware of the seriousness of global warming to some extent. As for other environmental and ecological problems, the respondents had lower levels of concerns and awareness of the seriousness of overpopulation and invasive species. Climate change and global warming are better known due to increasing scientific evidence on global warming and its confirmation, deeper impacts due to actual changes in the surrounding environment, media reporting and propagation, the public's attention and popularity of knowledge of climate change and global warming, international conferences related to climate change and global warm-

ing, and the promotion of strategies (such as the United Nations Framework Convention on Climate Change and the Kyoto Protocol). Therefore, environmental problems due to global warming have also received increasing attention. The public is likely to gradually become more aware to the seriousness of the global-warming problem.

Test of the difference between respondents' socioeconomic characteristics and levels of their concern and awareness of the seriousness of global warming

An ANOVA was used to test for differences between respondents' socioeconomic characteristics and levels of concern and awareness of the seriousness of global warming; if a significant difference existed then Duncan's multiple-range test was used to explain the difference. The results are shown in Table 3. Respondents had significant differences between the level of their concern about global warming and their age as well as education, while other socioeconomic characteristics showed no significant differences. The respondents with a higher education were significantly more concerned about global warming than those with lower education. As to the realization of the seriousness, there was a significant difference between education and occupation, while other socioeconomic characteristics showed no significant differences. Respondents with a senior high school education had significantly higher awareness of the seriousness of global warming than those with less than a senior high school education and more than a graduate school

Table 2. Respondents' awareness of environmental and ecological problems

Environmental and ecological problem	Level of concern		Level of awareness	
	Mean	Standard deviation	Mean	Standard deviation
Global warming	6.20	1.07	6.31	1.05
Water pollution	6.09	1.17	6.07	1.17
Air pollution	6.07	1.13	6.08	1.04
Climate anomalies	6.02	1.18	6.06	1.18
Inappropriate human development	5.88	1.31	6.09	1.20
Ozone hole	5.83	1.33	5.98	1.22
Excessive use of the earth's resources	5.80	1.27	5.96	1.22
Garbage and waste disposal	5.77	1.30	5.51	1.42
Floods, landslides	5.67	1.40	5.83	1.39
Land subsidence	5.22	1.60	5.32	1.51
Loss of biodiversity	5.15	1.54	5.40	1.40
Invasive species	4.81	1.74	4.85	1.70
Overpopulation	4.55	1.76	4.53	1.69

Table 3. Different socioeconomic characteristics and awareness levels about global warming

Socioeconomic characteristic	Level of concern	Level of severity	Duncan's multiple-range test
Gender	0.11	0.15	
Age	2.71*	0.9	46~55 > 25 yr of age
Marital status	1.37	0.72	
Educational level	3.07*	3.72*	Senior high school, university (college), graduate school and above > less than senior high school and beyond graduate school
Occupation	1.86	2.46*	Military, civil servants, teachers, business, engineers, self-employment, housekeepers, retired > students, Unemployed
Personal monthly income	0.27	0.62	
Place of residence	0.27	1.82	
Involvement in any environmental or religious groups	0.21	0.01	

* $p < 0.05$; each entry value in the table is the F -value. This table is the result of averaging the "level of concern" and the "level of severity" and conducting an ANOVA and post-hoc test on different socioeconomic characteristics.

education. Respondents who were students and had no job had lower significant differences in their awareness of the seriousness of global warming than those in the other

categories. In a previous study, Whitmarsh (2005) showed that male, highly educated (university), and middle-aged respondents' levels of awareness and understanding of

climate change were higher. Other studies found that females paid greater attention to the impacts of climate change, believed more than males that climate change was mainly caused by human activities, and worried more than males about climate change (DEFRA 2002, O'Connor et al. 2002, Bibbings 2004). More people aged 45~64 yr (78%) had heard about climate change than those 18~25 yr old (63%) (Whitmarsh 2005). Those of 25 yr and over 65 yr of age had less understanding of the causes of the impacts of climate change (DEFRA 2002, Hargreaves et al. 2003, Bibbings 2004). Other studies showed that in general, females were more concerned about environmental issues and their risks than males (Baldassare and Katz 1992, Witherspoon and Martin 1992, Stern et al. 1993, Hampel et al. 1996, Pidgeon and Beattie 1998, Barnett and Breakwell 2001). Some studies showed that young people were less concerned about climate change and other environmental issues than elderly people (Witherspoon and Martin 1992, Christie and Jarvis 2001, DEFRA 2002, Bibbings 2004). People with certain personal socioeconomic characteristics, such as educational level, age, gender, occupation, and ethnicity, differed in their understanding of climate change issues (Aoyagi-Usui et al. 2003, Ester et al. 2003, Aoyagi-Usui 2008).

Respondents' attitudes toward global warming

Among the 20 items asked about attitudes towards global warming, the 4 items of "reducing greenhouse gas emissions is what everyone must to do" (mean, 6.44), "human behavior is the major source causing global warming and climate anomalies" (mean, 6.26), "climate anomalies caused by the greenhouse effect and global warming are getting worse" (mean, 6.20), and "I am will-

ing to change some habits to improve the environmental degradation trends" (mean, 6.12) had the highest levels of awareness. In contrast, the following 6 items had lower levels of awareness "reducing greenhouse gas emissions is not my business" (mean, 1.80), "the reduction of greenhouse gas emissions should be done by other countries" (mean, 2.09), "the seriousness of global warming does not affect me" (mean, 2.46), "the global-warming problem is not really as serious as reported by the media" (mean, 2.69), "there is not enough scientific evidence to prove that global warming is really happening" (mean, 2.81), and "climate anomalies and global warming are environmental problems that cannot be modified by humans" (mean, 3.11) (Table 4). Such results show that in recent years, the media's propagation of a large amount of information related to climate anomalies and global warming has made respondents concerned about these issues. Respondents have received the message to some extent, and were personally willing to make adjustments, rather than viewing those issues as something not related to themselves.

Using an item analysis and reliability estimates for all 20 items on respondents' attitudes toward global warming, correlations of items 15, 13, 9, 8, 7, and 4 were < 0.30 , and hence those items were deleted. After deletion, the total Cronbach's α value increased from 0.83 to 0.92. We conducted a factor analysis on the remaining 14 items, and used a principle component analysis to extract common factors, which were determined according to eigenvalues of > 1 , and were transformed using orthogonal varimax rotation, in order to increase the factors' explanatory ability. The analyzed results are shown in Table 5, which shows that by the factor analysis, 2 common factors were extracted, and the total variance explained was 62.05%.

Table 4. Reliability of respondents' attitudes towards of global warming

Global-warming issue	Mean	Standard deviation	Correlation coefficient	Deleted value of α
14. Everyone must reduce greenhouse gas emissions.	6.44	1.19	0.38	0.83
3. Human behavior is the major cause of global warming and climate anomalies.	6.26	1.08	0.44	0.83
2. Global-warming and climate anomalies caused by the greenhouse effect are becoming more serious.	6.20	1.09	0.52	0.82
19. I would like to change some habits in order to reduce environmental degradation.	6.12	1.14	0.56	0.82
18. I am willing to do my best to reduce greenhouse gas emissions.	6.00	1.25	0.59	0.82
10. In order to reduce greenhouse gases, energy consumption should be reduced.	5.97	1.40	0.46	0.82
12. I am very worried about the impacts of global warming.	5.89	1.35	0.61	0.82
1. The emission of a large amount of greenhouse gases is the main cause of climate anomalies.	5.87	1.19	0.52	0.82
16. I think that the government should pass legislation to regulate greenhouse gas emissions as soon as possible.	5.77	1.54	0.53	0.82
11. Recent climate anomalies were likely caused by global warming.	5.73	1.38	0.53	0.82
20. I am willing to spend more money buying products beneficial to the environment.	5.63	1.59	0.59	0.82
5. I will pay attention to messages about global warming.	5.50	1.35	0.57	0.82
6. Global warming has affected my daily life.	5.40	1.45	0.52	0.82
17. I can accept an income reduction due to a reduction in greenhouse gas emissions.	4.88	1.78	0.51	0.82
4. Climate anomalies and global warming are environmental problems that cannot be modified by humans.	3.11	1.98	0.13	0.84
7. There is not enough scientific evidence to prove that global warming is really occurring.	2.81	1.78	0.24	0.84
8. Global-warming problems are not really as serious as reported by the media.	2.69	1.69	0.21	0.84
9. The seriousness of global warming does not affect me.	2.46	1.91	0.25	0.84
13. The reduction in greenhouse gas emissions should be done by other countries.	2.09	1.76	0.27	0.83

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15. Reducing greenhouse gas emissions is not my business.	1.80	1.60	0.26	0.83
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The α value indicates the value of Cronbach's α coefficient of reliability and is taken as the standard test, in which $\alpha < 0.30$ is not trusted; $0.30 < \alpha < 0.40$ is for the initial study, with strained credibility; $0.4 < \alpha < 0.50$ has a little confidence; $0.50 < \alpha < 0.70$ is credible (the most common reliability range); $0.70 < \alpha < 0.90$ is very credible (second most common reliability range); $0.90 < \alpha$ is very credible.

Table 5. Factor analysis of respondents' attitudes on attitudes towards global warming

Item	Factor loading	Variance (%)	Value of α
Dimension of factor one: actions to improve global warming			
19. I would like to change some habits in order to improve environmental degradation.	0.84	31.70	0.88
18. I am willing to do my best to reduce greenhouse gas emissions.	0.82		
20. I am willing to spend more money buying products beneficial to the environment.	0.80		
17. I can accept an income reduction due to a reduction in greenhouse gas emissions.	0.65		
16. I think that the government should pass legislation to regulate greenhouse gas emissions as soon as possible.	0.67		
14. Everyone must reduce greenhouse gas emissions.	0.66		
5. I will pay attention to messages about global warming.	0.56		
Dimension of factor 2: awareness and concern about global warming			
2. Global warming and climate anomalies caused by the greenhouse effect are becoming more serious.	0.89	30.35	0.88
1. The emission of a large amount of greenhouse gases is the main cause of climate anomalies.	0.86		
3. Human behavior is the major cause of global warming and climate anomalies.	0.74		
11. Recent climate anomalies were likely caused by global warming.	0.68		
12. I am very worried about the impacts of global warming.	0.66		
6. Global warming has affected my daily life.	0.56		
10. In order to reduce greenhouse gases, energy consumption should be reduced.	0.50		

KMO = 0.919; Bartlett's test of $\chi^2 = 2863.663^{***}$; 62.05% of total variance; the overall value of $\alpha = 0.92$.

Factor 1 contained 7 items (5, 14, 16, 17, 18, 19, and 20), which explained 31.70% of the total variance, and Cronbach's α value of the internal consistency was 0.88. This group of items covered people's attitudes to global warming, including "I will pay attention to

messages about global warming," "I am willing to do my best to reduce greenhouse gas emissions," "everyone must work to reduce greenhouse gas emissions," "I would like to change some habits in order to improve environmental degradation," "I am willing to

spend more money buying products beneficial to the environment,” “I can accept an income reduction due to a reduction in greenhouse gas emissions,” and “I think that the government should enact legislation regulating greenhouse gas emissions as soon as possible,” so they were labeled “actions to improve global warming.” Factor 2 contained items 1, 2, 3, 6, 10, 11, and 12, which explained 30.35% of the total variance, and Cronbach’s α value of factor internal consistency was 0.88. The items in this factor were correlated with the respondents’ knowledge and feelings about global warming, such as their feelings about the seriousness of global warming and climate anomalies caused by the greenhouse effect, major sources of and reasons for global warming and climate anomalies, and feeling the effects of global warming, so they were labeled “awareness and concern about global warming.”

Testing differences between respondents’ socioeconomic characteristics and factors related to global-warming issues

An ANOVA was used to test differences in respondents’ socioeconomic characteristics and factors on global-warming issues; if a significant difference was found, then Duncan’s multiple-range test was used to explain the difference. The analyzed results are shown in Table 6, which are summarized as follows. The respondents’ different socioeconomic characteristics had no significant effects on the “awareness and concerns about global warming”, but education and occupation had significant effects on the “actions to improve global warming”. Then, according to Duncan’s multiple-range test, the ratio of respondents with more than a senior high school education were significantly higher than those self-educated or with less than a senior high school education in the “actions

to improve global warming” dimension. The ratio of respondents with occupations of military, civil servants, teachers, businesspeople, self-employed, and retired were significantly higher than students; in addition, the ratio of retired respondents was also significantly higher than housekeepers.

Awareness of the “planting trees for carbon sequestration” policy

As shown in Table 7, respondents who knew about the government’s promotion of “energy saving and carbon sequestration” accounted for 88.3%, while about 11.7% of respondents did not know. The proportions of respondents who had heard about a “carbon-neutral” or “low-carbon” lifestyle and those who had not were very similar, each of which accounted for 50.3 and 49.7%, respectively. Planting trees is not only one of the feasible strategies for “energy saving and carbon sequestration”, but is also one of the ways to achieve personal or business carbon neutrality. Carbon offsets, mainly in terms of planting trees, are one of the ways to respond to climate change. For the concept of carbon neutrality, participants thought that tourists also had the responsibility to use carbon offsetting, in creating and protecting natural carbon sinks (generally referring to forests) to absorb CO₂ (Becken 2004). Therefore, some carbon-offset programs encourage consumers to provide funds for planting trees or forest management to achieve individual carbon emission reductions (Carswell et al. 2003). In addition to the benefits of carbon sequestration from planting tree, there are other co-benefits, such as enhancing biodiversity (Becken 2004, Egerton et al. 2007). According to a survey conducted by the Japanese Fuji Research Graduate School, about 82% of respondents thought that carbon sequestration (mainly in terms of planting trees)

Table 6. Effects of socioeconomic characteristics on attitudes toward global warming

Socioeconomic characteristic/dimension	Actions to improve global warming	Awareness and concerns about global warming	Duncan's multiple-range test
Gender	0.388	1.727	
Age	2.069	0.583	
Marital status	0.304	1.588	
Educational level	2.721*	1.544	Less than senior high school < senior high school, university, and graduate school and above
Occupation	2.409*	1.902	Military, civil servants, teachers, business, self-employed, and others > students
Retired > students, housekeepers			
Personal monthly income	1.771	1.527	
Place of residence	0.882	0.238	
Participation in organizations	0.674	0.257	

* $p < 0.05$; each entry value in the table is the F -value. This table is the result of averaging the “level of concern” and the “level of severity” and conducting an ANOVA and post-hoc test on different socioeconomic characteristics.

could slow down global warming. From a survey conducted by the Massachusetts Institute of Technology (USA), only 23% of respondents thought that carbon sequestration could slow global warming, but up to 73% of people were uncertain about the reduction. The difference between the 2 surveys possibly resulted from differences in country conditions, the country's greenhouse gas-reduction policies, cultural differences, and retrieval of information on carbon sequestration. Results of the investigations between the 2 countries showed great differences (Curry 2004). Therefore, we know that citizens of different countries have different awareness levels about whether planting trees can slow down global warming. Curry et al. (2004) analyzed individuals' opinions on feasible strategies for slowing down global warming, for which about 66% of respondents thought

that carbon sequestration could reduce CO₂. Curry (2004) conducted another survey and found that 67% of respondents thought that carbon sequestration (planting trees) might reduce CO₂, but that was still less than the proportions of respondents who thought that “using solar energy” (82%), “improving energy efficiency” (81%), “using energy-efficient vehicles” (81%), and using “wind power” (76%) could reduce CO₂. Curry et al. (2005) investigated the UK public, and 76% of respondents believed that planting trees can reduce the proportion of CO₂. In a survey conducted by Leiserowitz (2003), about 49% of American respondents would plant trees in response to global warming. Reiner et al. (2006) surveyed the ratios of the possibility of using carbon sequestration (planting trees) for carbon reduction in the UK, Japan, the US, and Sweden, in which nearly 90% of

Table 7. Respondents' awareness of the issue of planting tree

Item	Percentage (%)
Aware that the government is promoting “energy saving, carbon sequestration” actions?	
Know	88.3
Do not know	11.7
Had heard of a “carbon-neutral” or “low-carbon” lifestyle?	
Heard	50.3
Never heard	49.7
Had considered or was already engaged in planting trees to achieve carbon sequestration?	
No	18.6
Yes	81.4
Types of participation in “planting trees for carbon sequestration”	
Planting trees on their own land	37.3
Participating in planting trees activities by the government and relevant organizations	35.1
Providing land to the government to plant trees	33.2
Donating money to participate in the tree-planting activities of the government and relevant organizations	20.0
Planting trees in their own garden or balcony	79.0
Taking care of planted trees	
Not willing	26.8
Willing	73.0

Japanese respondents' answers were positive.

In this study, 81.4% of respondents were considering or had been engaged in tree-planting activities to achieve the objective of reducing carbon, in which among the 5 suggested tree-planting programs, planting trees in their own garden or balcony accounted for the highest percentage (79.0%), while paying or donating money to support the government and relevant organizations in their tree-planting activities accounted for the lowest percentage (only 20.0%). If domestic non-governmental environmental organizations, universities, or government departments take money donated by individuals or businesses to carry out “planting tree for carbon sequestration” activities and take care of those planted trees for 20 yr, then the ratio of the

respondents who were willing to participate in such a program increased to 73.11%.

The analyzed results in Table 8 are summarized as follows. Respondents who did and those who did not know that the government was promoting “energy saving and carbon sequestration” actions had significant differences in the “actions to improve global warming” dimension, in which the ratio of those who knew about the actions was significantly higher than those who did not know about the actions. Respondents who had and those who had not heard about a “carbon-neutral” or “low-carbon” lifestyle also had significant differences in the 2 dimensions of “actions to improve global warming” and “awareness and concerns about global warming”, in which the ratio of those who had heard of the

Table 8. Effects of “planting trees for carbon sequestration” on the “global-warming issues” dimensions

Socioeconomic characteristics/dimension	Actions to improve global warming	Awareness and concerns about global warming
Do you know that the government is promoting “energy saving for carbon sequestration” actions?	4.028*	2.045
Have you heard about a “carbon-neutral” or “low-carbon” lifestyle?	19.577***	9.267**
Are you considering or already engaged in tree-planting activities to achieve the purpose of reducing carbon?	8.572**	6.02*

This table applied an independent-sample *t*-test to investigate the variance test of 3 variables on 2 dimensions (i.e., actions to improve global warming, and awareness and concerns about global warming).

2 terms were significantly higher than those who had not. Respondents who were considering or had already been engaged in planting trees to reduce carbon emissions were significantly higher than those with no actions in the 2 dimensions of “actions to improve global warming” and “awareness and concerns about global warming”. Therefore, to promote policies, it is important that the public understand the policy contents, which will increase their willingness to participate in the program.

In other studies, Macnaghten and Jacobs (1997) and Weaver (2002) found that if the public understands environmental issues to a greater extent, it would be easier for them to take appropriate actions. Sampei and Aoyagi-Usui (2009) analyzed Japan’s newspaper reports and public opinion about global warming from 1998 to 2007, and suggested that increasing the public’s understanding would help communication about mitigating global warming.

CONCLUSIONS

The public’s attitudes are key factors in mitigating climate change, global warming, and other environmental issues. Different personal socioeconomic characteristics and

awareness of related knowledge also cause differences in attitudes and behaviors toward global warming and other environmental problems. Since “planting trees for carbon sequestration” is one of the feasible mitigation strategies for global warming, it is necessary to understand the public’s attitudes, so as to frequently promote tree-planting programs. Therefore, in this study, we conducted a mail survey to analyze the public’s attitudes and awareness of global warming, and further explored their participation in “planting trees for carbon sequestration” in Taiwan. A review of the literature showed that with more scientific evidence of climate change and global warming, the deepening impacts caused by real change in surrounding environments, media coverage and propagation, the popularity of information related to climate change and global warming, international conferences on climate change and global warming, and promotion of adopting strategies have focused increasing attention on the issue of global warming. In this survey on 13 listed environmental and ecological problems, the respondents were most concerned about global warming and also thought that global warming was the most serious environmental and ecological problem.

By the ANOVA, we found that significant differences existed between the respondents' level of concerns and their age and education, but there was no significant difference in other socioeconomic characteristics. Respondents 46~55 yr old were more concerned than those older than 25 yr. Respondents with a senior high school education were more significantly concerned about global warming than those with less than a senior high school education and those with more than a graduate school education. By using a factor analysis, 2 dimensions of "actions to improve global warming" and "awareness and concerns about global warming" were extracted, which explained 62.05% of the total variance.

According to the ANOVA, there were no significant differences in the different socioeconomic characteristics in the "awareness and concerns about global warming" dimension, but there were significant differences in education and occupation in the "actions to improve global warming" dimension. By Duncan's multiple-range test, we found that the ratio of the respondents with more than a senior high school education was significantly higher than that with a primary school education or self-educated for the "actions to improve global warming" dimension. The ratio of respondents who were in the military, civil servants, teachers, businesspeople, self-employed, other, and retired were significantly higher than students; the ratio of retired respondents was also significantly higher than housekeepers.

Respondents who were considering or had been engaged in planting trees to achieve the purpose of reducing carbon accounted for 81.4%. For 5 suggested tree-planting programs, planting trees in their own garden or balcony accounted for the highest proportion (79.0%). For "planting trees for carbon sequestration", 73.11% of respondents were

willing to participate. The ratio of the respondents who were considering or had already been engaged in planting trees in the 2 dimensions of "actions to improve global warming" and "awareness and concerns about global warming" were significantly higher than those with no actions. Therefore, to promote policies, it is important that the public understands the policy contents, and the public's willingness to participate in planting trees activities for carbon sequestration will also increase.

The results of this study are subject to the following limitations. Our questionnaires were issued by post. After urging respondents to reply to our questionnaires, the final overall response rate was only 16.7%. We found that highly educated respondents accounted for the the greatest proportion of the received questionnaires, so the samples received might not represent the general Taiwanese public, and may lead to a random sampling error (i.e., the difference between sample statistics and population parameters results from probability when selecting samples). Lue and Chen (1995) indicated that the overall response rate by post usually falls between 10 and 40%. In addition, Lee (1994) studied the influence of rewarding incentives on a farmers' questionnaire response rate by post, in which the overall response rates in different situations were 4.80, 6.98, 10.84, and 10.25%. A low overall response rate by post is unavoidable. As a result, in subsequent research, it is suggested that researchers should provide more incentives when issuing questionnaires (Cycyota and Harrison 2006). For example, we could apply the following schemes to increase the overall response rate: provide gift incentives (Church 1993, Hopkins and Gullickson 1993, Yammarino et al. 1991), improve the questionnaire design (Nowack 1990, Roszkowski and Bean 1990, Yammarino et al. 1991),

focus on issuing questionnaires to respondents that can send mail conveniently, and increase the times of reminding respondents (Roth and BeVie 1998, Cycyota and Harrison 2006).

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FOOTNOTES

- 1) Baron and Greenberg (1990) mentioned that "attitude" includes evaluation, recognition, behavior, etc., while Zimbardo and Leippe (1991) divided attitude into 3 levels: consciousness, emotion, and behavior. Therefore, consciousness is a part of attitude. Also, cognition and attitude are not equivalent, and have different meanings.
- 2) Validity is the correctness of a measurement, meaning the degree to which the characteristics of concern or function is measured by tests or other measurement tools. Higher validity implies a higher degree to which the measured results reflect actual characteristics. This study applied the "expert validity" method. In order to avoid a situation where the questionnaire content cannot achieve sufficient precision, the questionnaire should be designed to facilitate respondents' responses. Hence, our experiments were first pretested and were based on purposive sampling. Five questionnaires were issued to scholars with expertise in related fields. They examined the feasibility of the questionnaire content, revised incomplete descriptions, and deleted partial question items, so that a final questionnaire was achieved which guaranteed expert validity.
- 3) Five experts were asked to assist in examining the questionnaire content, in which each question had 3 options: "agree", "agree after revised", and "disagree". This study further integrated the experts' advice and suggestions to increase the content validity of the questionnaire, and deleted the questions that satisfied the following conditions: (1) the ratio of disagreeing with the question (including blank answers) exceeded 18%; (2) the ratio of revising and disagreeing with the question at the same time (including blank answers) exceeded 18%; and (3) if the question was suggested to be transferred to another level, it should be deleted (Chiou 2011).
- 4) First, random sampling error is a kind of sampling error. Heffernan (2006) indicated that the level of random sampling error can be controlled by selecting the size of random samples. This study collected 333 effective samples, which should have effectively decreased the sampling error. Second, nonsampling error includes processing errors, response errors, and nonresponse errors. This study used a postal questionnaire, which may have produced unavoidable "nonresponse errors". This is a limitation of the study.
- 5) Respondents who had graduated from university (college) or higher accounted for 69.7%, which shows that the number of highly educated respondents who mailed their surveys back was greater than the less-educated. Indeed, this may have resulted in a statistical error, but the reason is that our study conducted the survey by mail, which cannot totally avoid biased statistics. Hence, mailing the survey is a limitation of the study.