

Voluntary Support of Scientific Research: A Road to a more Sustainable Future

Hanne M. EDVARSEN*, Staša PUŠKARIĆ

American College of Management and Technology, Don Frana Bulića 6, 20000 Dubrovnik

*Corresponding author: hme9554@rit.edu

This study investigated the awareness about the threats of global warming and the attitude of a random population to actively participate in supporting research and development of novel methods to mitigate the consequences of global warming. The survey includes responses from 195 randomly selected people of various profiles. The study found that the respondents generally consider global warming to be a real problem and a threat to our society and that the governments and corporations are not doing enough to deal with global warming. Respondents felt that they can be responsible consumers and choose green products and services to prevent pollution, and believe there is still time to change our behavior by cutting emissions and pollution levels in order to prevent global warming. Additionally, the study found that a small but significant percentage of respondents considered investing a larger amount of money in a safe project that develops methods to reverse global warming. Finally, the reasons for these attitudes are discussed as well as the possible solution for the problem.

Key words: global warming, geoengineering, atmospheric carbon dioxide removal, sequestration

INTRODUCTION

With all the efforts undertaken so far to mitigate global warming, concentrations of atmospheric carbon dioxide are steadily rising (NOAA, 2012). The world is warming, and consequential climate changes are threatening natural and human environment by loss of biodiversity, sea level rise and increased frequency of extreme weather events (Pearce, 2006). Climate change and extreme weather events are also a consequence of warming atmosphere (Min et al., 2011). Coumou & Rahmstorf (2012) have demonstrated that extreme weather events during the last decade including heatwaves and precipitation are directly related to human activities. Additionally to warming, the economic development and consumer behavior in the developed countries have also caused heavy environmental degradation (UN report, 2011).

The maximum concentration of atmospheric CO₂ during the past 400,000 years was 300ppm, about 10500 years ago (Ruddiman, 2005). The same study postulates that the rise of agriculture, farming and growth of small human settlements was the first human induced change in natural patterns of atmospheric carbon dioxide and methane.

The International Panel on Climate Change has issued a recommendation that the concentration of atmospheric CO₂ should be at the maximum 450 ppm (The Royal Society, 2009).

Concentration of atmospheric CO₂ in March 2012 was 394.45ppm with an average annual increase of 2 ppm during the last decade (NOAA, 2012). With the current level of emissions we can expect an average global warming between 2 to 5°C (IPCC, 2007). There is a general agreement that temperature increase of 2°C above the pre-industrial times can have catastrophic and unpredictable impacts on the climate, as we know today (The Royal Society, 2009).

Johannessen (2010) informs that the average global temperature has already increased 0.8°C above the pre-industrial period. Their climate model indicates that the 1.5-degree goal can be reached

only if CO₂ is extracted from the atmosphere. They further postulate that if we want to keep within the 2 degrees target, CO₂ emissions must be cut as soon as possible, and reduced at least 65% within the next 30 years.

At the Earth Summit 1992, it was agreed that the world should prevent dangerous climate changes (Pearce, 2006). The first step was the Kyoto Protocol, a legally binding agreement for developed countries to reduce greenhouse gas (GHG) emissions according to the preset targets (United Nations Framework Convention on Climate Change, 2012). The foundation of this agreement is that all the countries involved should reduce their GHG emissions for 5% as compared to their emissions in 1990. Furthermore, countries should meet the targets primarily through national emission cuts. However, if their targets are not met, there is a possibility to utilize the three market-based mechanisms, which include: a) emissions trading, known as the carbon market, b) clean development mechanism (CDM), and c) joint implementation. If a country has not utilized their emission allowance, or needs to emit more than the cap, they can sell or buy CO₂ shares, called AAU's (Assigned Amount Units) on the emission trading market. The CDM enables a country to execute a CO₂ emission reduction project in a developing country and use the Certified Emission Reduction (CER) credits to meet their own emission goals. A joint implementation allows member countries to collaborate and invest in projects that will generate Emission Reduction Units (ERUs) in one member country and utilize the ERUs to meet their own goals (United Nations Framework Convention on Climate Change, 2012).

The voluntary carbon market is another CO₂ market, where businesses and people can buy and sell CO₂ shares with no legally binding agreements or memberships regulations (Hamilton et al., 2010). One market segment is the Over The Counter (OTC) market where greenhouse gas emissions are converted and traded as tons of CO₂ equivalents (tCO₂e). Anyone who is certified can trade their Verified

Emission Reductions (VERs), as tCO₂e, from emission reduction projects that are solely implemented to reduce GHG emissions, not enforced by regulation (Hamilton et al., 2010). Both CER credits from the Clean Development Mechanism under the Kyoto protocol and VERs are traded on the voluntary market (Kollmuss et al., 2008). Moreover, the voluntary market enables businesses, governments and people to compensate for their emissions by buying carbon offsets. Any new project that plans to sell VERs must be first evaluated and approved under one of 18 standards (Hamilton et al., 2010).

Unlike the Clean Development Market (CDM), the voluntary market does not have a common regulation for verification of VERs (Kollmuss et al., 2008). CDM regulations are most commonly used as a guideline for verification of new carbon offset projects. The voluntary carbon market is much smaller than the regulatory market, but Willow Rivers Wealth (n.d) predicts the carbon market to expand rapidly over the coming years.

The Royal Society (2009) recommends a continuing development of the carbon market systems, but also recommends further research in geoengineering the climate, as it could become a needed contributing solution to the global warming threats. The reported methods are Carbon Dioxide Removal techniques, which remove the CO₂ from the atmosphere, and Solar Radiation Management techniques that will reflect some of the sun's radiation back into the atmosphere in order to cool the earth. The report states that CO₂ removal techniques are preferred over the Solar Radiation Management techniques. This is because it is better for the overall environment to reduce the CO₂ levels, not only reduce the temperature. The CO₂ sequestration methods evaluated in the report include land-based reforestation, afforestation and preventing deforestation, which prove to be safe and affordable, but not too effective since they cannot remove carbon permanently. Other methods evaluated in the report are the novel methods; land carbon sinks, Bioenergy and Biofuels and Bioenergy with CO₂ capture and sequestration, which are

safe methods, but are evaluated to be expensive and not so effective. In addition, enhanced weathering on land and oceans are expected to be effective but very expensive, and CO₂ capture from the air is feasible and safe, but the process still requires large amounts of energy and is therefore considered too costly. At last the ocean fertilization methods are evaluated to be low in effectiveness, costly and not safe. At the time the report was released, it is stated that there were no successful novel geoengineering techniques available. Therefore the report encourages further research, and suggests that the Royal Society should, in co-operation with other international scientists, develop a code of practice for geoengineering the environment (The Royal Society, 2009).

There are various new technologies being developed with the aim to contribute in solving global problems. Many new ideas are marginalized and thus not funded as a consequence of lack of understanding or just being "out of the box". For example, a new geoengineering method in this category is the GEA@275 ocean sequestration technology; a new approach in iron seeding of the Southern Oceans (Puškarić, 2010) that successfully replaces iron fertilization (e.g. Boyd et al., 2000; Buesseler et al., 2005). The GEA@275 method has been tested in the lab and in the ocean, and shows to be a safe and economic method of permanently removing CO₂ from the atmosphere. A US patent application has been filed to protect the method, and currently additional funding is needed to further test and develop the process.

It could be postulated that we need to do much more than we are currently doing to stabilize the rising concentrations of atmospheric CO₂, and that the solution might be found in direct involvement of the non-institutional population in the form of "community supported scientific research", therefore not the rich, non-corporate and non-decision making individuals. The goal of this study was to test this hypothesis by measuring the levels of understanding and interest in direct involvement to participate in such a project.

METHODS

A self-administered online survey was constructed to test the awareness, willingness to participate/pay for research and development of new global warming abatement projects on the particular case of the above-mentioned GEA@275 technology. Clipboard survey software was used for data collection and analysis (www.clipboard.rit.edu). Prior to posting the survey, the questionnaire was tested on a small group of fellow students and faculty members and distributed by e-mail and Facebook.

The respondents were asked to categorize themselves by their gender, occupancy and age. The questionnaire was constructed to lead the respondents into thinking about the current situation, about the options available to fight global warming, and the possible tools available to be developed to prevent man made global warming. The respondents were asked about their current knowledge about global warming, involvement of governments and corporations in projects focused on solving problems related to global climate change, do they think individuals matter, can we reverse the trends in global warming and climate change if we cut emissions and pollute less in the future, and who should own new technologies to be implemented.

RESULTS

The study population included anyone with an Internet connection and an e-mail address or a Facebook account. The survey includes 195 random responses of which 91 (46.7 %) were male, and 100 (51.3 %) were female and 4 people did not inform about their gender.

Table 1 shows the general attitude of the respondents towards global warming. A total of 82.5 % answered that they consider global warming to be a real problem and a threat to our society. 17.5 % did not consider global warming a real threat.

Table 1. Attitude towards global warming

	Total (%)
<i>Do you consider global warming to be a real problem and threat to our society?</i>	
Yes	82.5
No	17.5

Attitudes about governments and corporations are doing enough to deal with man-made global warming are shown in Table 2. 81 % do not agree with the statement. A total of 5.6 % think that governments are spending enough on research projects, and 3.5 % think that corporations are cutting enough emissions. A total of 5.2 % assume that both governments and corporations are doing enough to prevent global warming. Only 4.7 % express that global warming is not a problem that needs to be dealt with.

Table 2. Perception on the involvement of governments and corporations in mitigation of consequences of man-made global warming

	Total (%)
<i>Do you think governments and corporations are doing enough to deal with global warming?</i>	
Corporations are cutting down greenhouse gas emissions.	3.5
Governments are spending enough taxpayer's money on research projects.	5.6
Yes, they are both doing enough to cut greenhouse gas emissions and prevent global warming.	5.2
No	81
Global warming is not a problem that needs to be dealt with.	4.7

Table 3 shows the perception about the role of the individuals in preventing global warming. Over half of the respondents, 51 %, think that they can be responsible consumers and choose green products and services to prevent pollution. 28 % said that they cannot make a difference, the big polluters is

the industry. 15 % think they could make a difference, but don't know how, and only 6 % don't care about global warming.

Table 3. Attitudes towards the importance of individuals

	Total (%)
<i>Do you think you as an individual can make a difference in preventing global warming?</i>	
Yes, I can be a responsible consumer and choose green products and services to prevent pollution.	51
Yes, but I don't know how.	15
No, the major problem are the industries; my actions won't make a difference.	28
No, and I don't care about global warming.	6

Table 4 shows the attitude about the possibility of reversing the trends in global warming and climate change. The majority of the respondents (74 %) are positive and believe there is still time to change our behavior by cutting emissions and pollution levels in order to prevent global warming. 26 % of the respondents think that we must use novel methods and new technologies to manipulate and reverse the warming.

Table 4. Attitudes about reversing the current trends of global warming

	Total (%)
<i>Do you think we can reverse the trends in global warming and climate change if we cut emissions and pollute less in the future?</i>	
Yes, there is still time to change our behavior.	74
No, we must use modern methods to manipulate and reverse the warming.	26

Table 5 shows the opinions on who should own a technology that could reverse global warming. The largest group of 38 % believes a coalition of government should own the technology. The second largest group, 19.5 % of the

respondents, did not find the alternatives provided a good solution, and answered others. 14.5 % think a coalition of governments, private investors and corporations should own it, 11.3 % think a government should own it, 8.2 % believe in private ownership and 7.7 % believe a corporation should have more power and be the owner of such a technology. 2 respondents did not answer the question.

Table 5. Attitudes about the ownership of new geoengineering technologies

	Total (%)
<i>In the case a method to reverse global warming was available, who should own the technology?</i>	
A government.	11.3
A coalition of governments.	38
A big corporation.	7.7
Private investors.	8.2
A corporate-private partnership.	14.5
Others.	19.5

Table 6 shows the distribution of opinions about individual investment in a project that could reverse global warming. The responses were diverse, and the largest group contained 34.5 % of the respondents that would support research in developing new technologies, but not invests their own money. 17.5 % would invest between US \$20 and \$500 for company shares, 16 % would invest up to US \$20 for a company share, 13.4 % would invest a larger amount of money for company shares, 9.7 % don't support the approach of researching alternative methods and wouldn't invest money and 8.2 % would donate a small amount of money.

Table 6. Attitude towards investment in a geoengineering project

	Total (%)
<i>If I could invest in a safe project that develops methods to reverse global warming, I would:</i>	
Donate a small amount of	8.2

money.	
I would invest up to \$20 US in a company share.	16
I would invest between \$20 to \$500 US in company shares.	17.5
I would invest a larger amount of money in company shares.	13.4
I support scientific research, but I wouldn't invest my money.	34.5
I don't support this kind of approach, and I wouldn't invest my money.	9.7

Table 7 shows the attitudes about different statements about global warming. A total of 14 % agreed with the statement that global warming is a natural process and it is not a threat to our society. A total of 22 respondents (11 %) agreed that solely the government should address human impact on global warming. A total of 53 % agree with the statement that the problems of global warming and associated climate change can only be solved if we all as individuals change our ways of living. 50 % of the respondents agreed with the statement that applying new methods can solve problems associated with global warming and technologies that make it possible to alter natural processes and reverse the damages made by greenhouse gasses. A total of 58 % agreed with the last statement that governments are not doing enough to deal with the problem; private investors must be involved in the process of developing new methods to prevent global warming. This corresponds with the responses of question 2 where 91 % of the same respondents also said that governments and corporations are not doing enough to deal with global warming.

Table 7. Attitudes of the respondents about different aspects of global warming

	Total (%)
<i>Check the statements that you agree with:</i>	
Global warming is a natural process and it is not a threat	14

to our society.	
Only governments should address human impact on global warming.	11
The problems of global warming and associated climate change can only be solved if we all as individuals change our ways of living.	53
Applying new methods can solve problems associated with global warming involving technologies that make it possible to alter natural processes and reverse the damages made by greenhouse gasses.	50
Governments are not doing enough to deal with the problem, private investors must be involved in the process of developing new methods to prevent global warming.	58

DISCUSSION

Literature shows that there is an agreement that the global warming currently happening is a threat to our society, and that we humans are partially guilty for the warming of our planet. Our results show that the majority of people are aware of global warming and of the threats it poses to our society. In 1992 it was agreed that the world should prevent global warming and decrease the CO₂ emissions. However, the atmospheric CO₂ concentration has continued to increase, and many criticize the Kyoto Protocol (Paterson, 2011).

Holmes (2012) revealed that the Heartland Institute is deliberately trying to create confusion and misinformation about the global warming, funded by the industry. Besides releasing several research documents and reports criticizing the consensus on man made global warming, they also have plans to develop an educational program aimed for implementation in elementary school so that the young are not educated about global warming according to the current agreed theories about global warming. The IPCC is the leading international body for the evaluation of climate change, and consists of thousands of international scientists, but it seems like a doubt about their information has been made. In addition to the IPCC a survey of 1372 climate scientist show that 97% of their publications agree with IPCC that GHG emissions are with 90% certainty pushing up temperatures. The Heartland Institute has created a Nongovernmental International Panel on Climate Change (NIPCC) and through the Global Warming Petition Project they have collected 31.487 signatures from scientists that disagree with the anthropogenic warming hypothesis posed by IPCC. However, when looking into the names on the list, few but any of the signatures belong to climate scientist or climatologists, rather veterinarians, happiness psychologists, or traffic engineers. The scary factor is that many seem to buy into the statements made by the Heartland Institute without looking into the real facts of the case.

This study shows that people are interested in investing in green technologies and methods to prevent global warming, however, if they don't get introduced to the ideas, they are less likely to invest. The results also show

that the majority of our respondents are interested in being aware consumers.

Even though the Kyoto Protocol regulations and the emission cut promises by the industrialized countries have not reduced the atmospheric CO₂ concentration, to some extent it has helped prevent an even higher increase in GHG emissions. The system is a good incentive for companies to implement emission reduction technologies, and make additional money on CO₂ share sales. If the industry is not willing to change by its own initiative, they are forced to do it under the Kyoto scheme. Also, if a technology like GEA@275 should be developed, the Kyoto or the voluntary carbon market would be the way to commercialize the technology and make return on investment. It is not likely that the world will change fast enough and be able to reduce GHG emissions by 65% in order to prevent warming over the 2°C as suggested by the scientists, so it is advised that further research is conducted in order to develop new clean energy technologies and biotechnologies that can extract the surplus CO₂ from the atmosphere. Just to achieve the proposed safe concentration of 350 ppm (European Environment Agency, 2011) at this moment it would be necessary to remove the amount in the range of 200 BtC. Additional approaches are necessary. Our results clearly indicate that people are willing to become actively involved in the research and development of novel approaches in mitigation of consequences of global warming. Therefore, the idea of voluntary support of scientific research has solid grounds to develop within the voluntary carbon market cluster and to contribute setting up the path towards a more sustainable future.

REFERENCES

- Boyd, P.W., Watson, J.A., Law, C.S., Abraham, E.R., Trull, T., Murdoch, R., Bakker, D.C.E., Bowie, A.R., Buesseler, K.O., Chang, H., Charette, M., Croot, P., Downing, K., Frew, R., Gall, M., Hadfield, M., Hall, J., Harvey, M., Jameson, G., LaRoche, J., Liddicoat, M., Ling, R., Maldonado, M.T., McKay, R.M., Nodder, S., Pridmore, R., Rintoul, S., Safi, K., Sutton, P., Strezpek, R., Tanneberger, K., Turner, S., Waite, A., and Zeldis, J. (2000) A mesoscale phytoplankton bloom in the polar Southern Ocean stimulated by iron fertilization. *Nature*, **407**, 695-702.
- Buesseler, K.O., Andrews, J.E., Pike, S.M., Charette, M.A., Goldson, L.E., Brzezinski, M.A., and Lance, V.P. (2005). Particle export during the Southern Ocean Iron Experiment (SOFEX). *Limnol. Oceanogr.*, **50**, 311-327.
- Coumou, D. , & Rahmstorf, S. (2012). A decade of weather extremes. *Nature Climate Change*, doi:10.1038/nclimate1452.
- CO2now.org (2011, December). Atmospheric CO₂ for November 2011. Retrieved April 12, 2012 from <http://co2now.org/>
- European Environment Agency. (2011). Climate change targets: 350 ppm and the EU two-degree target. Retrieved April 22, 2012 from <http://www.eea.europa.eu/highlights/climate-change-targets-350-ppm-and-the-eu-2-degree-target>
- Hamilton, A., Sjardin, M., Peters - Stanley, M., & Marcello, T. (2010, June 14). *Building Bridges: State of the Voluntary Carbon Markets 2010*. Retrieved April 22, 2012 from http://forest-trends.org/publication_details.php?publicationID=2433
- Holmes. B. (2012, February 25) Planting Seeds of Climate Doubt. *New Scientist*. 213, 2853. Retrieved from RIT Library database.
- IPCC. (2007) Climate Change 2007: Synthesis Report. *IPCC Fourth assessment Report (AR4)*. Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
- Johannessen, J. (December, 2010). 1,5 grader er urealistisk. [1,5 degrees are not realistic.] *Bjerknes Center for Climate Research*. Retrieved December 21, 2011 from <http://www.bjerknes.uib.no/pages.asp?id=1918&kat=2&lang=1>
- Kollmuss, A., Zink, H., & Polucar, C. (March, 2008). *Making sense of the voluntary carbon market: A comparison of carbon offset standards*. Retrieved from the World Wildlife Fund web page http://wwf.panda.org/about_our_earth/all_publications/index.cfm?uNC=50763266&uPage=2&uGlobalSearch=Making+sense+of+the+voluntary+carbon+market%3AA+comparison+of+carbon+offset+standards
- Min. S., Zhang. X., Zwiers. F.W., & Hegerl. G. C (2011, February 17) Human contribution to more-intense precipitation extremes. *Nature*, **470**, 378–381.
- Montzka. S. A., Dlugokencky. E.J., & Butler. J. H (2011, August 4) Non CO₂ greenhouse gases and climate change. *Nature*. **476**, 43–50.
- NOAA. (2012) Trends in atmospheric carbon dioxide. *Earth System Research Laboratory, Global Monitoring Division*. Retrieved April 18, 2012 from <http://www.esrl.noaa.gov/gmd/ccgg/trends/>
- Paterson. N. R. (2011, March). Global warming a critique of the anthropogenic model and its consequences. *Geoscience Canada*, **38**. Retrieved April 21, 2012 from http://findarticles.com/p/articles/mi_m0QQS/is_1_38/ai_n57783716/
- Pearce, F. (September 1, 2006.). Introduction: Climate Change. *New Scientist*. Retrieved December 13, 2011, from <http://www.newscientist.com/article/dn9903-instant-expert-climate-change.html>
- Puškarčić, S. (2010). A method of sequestering atmospheric carbon into a deep body of water. *United States Patent and Trademark Office*. Application Number 61/373,246 from 12 August 2010. Confirmation No. 1411.
- Ruddiman. W.E (2005, March) How did humans first alter global climate? *Scientific America*. **292**, 46-53.
- The Royal Society. (2009). *Geoengineering the climate: science, governance and uncertainty*. Retrieved March 23, 2012 from <http://royalsociety.org/policy/publications/2009/geoengineering-climate/>
- United Nations. (2011). World Economic and social survey 2011, the great green technological transformation. Retrieved from http://www.un.org/en/development/desa/policy/wess/wess_current/2011wess.pdf
- Paterson. N. R. (2011) Global warming: a critique of the anthropogenic model and its consequences. *Geoscience Canada*, **38**, 41-48.
- United Nations Framework Convention on Climate Change. (2012). Kyoto Protocol. Retrieved December 14, 2011 from http://unfccc.int/kyoto_protocol/items/2830.php
- Willow Rivers Wealth. (n.d). *Carbon credit industry report*. Retrieved December 10, 2011 from http://www.willowrivers.com/WR_Carbon_Credit_Market_Report.pdf