



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

ECONOMICS, ECOLOGY AND THE ENVIRONMENT

Working Paper No. 147

**Global Warming and the Future of
Pacific Island Countries**

by

Clem Tisdell

November 2007



THE UNIVERSITY OF QUEENSLAND

ISSN 1327-8231
**WORKING PAPERS ON
ECONOMICS, ECOLOGY AND THE ENVIRONMENT**

Working Paper No. 147

**Global Warming and the Future of
Pacific Island Countries¹**

by

Clem Tisdell²

November 2007

© All rights reserved

¹ .The draft of a paper prepared for a special issue of the *International Journal of Social Economics* on Pacific Island Countries being edited by Paresh Narayan

² School of Economics, The University of Queensland, Brisbane QLD 4072, Australia
Email: c.tisdell@economics.uq.edu.au

WORKING PAPERS IN THE SERIES, *Economics, Ecology and the Environment* are published by the School of Economics, University of Queensland, 4072, Australia, as follow up to the Australian Centre for International Agricultural Research Project 40 of which Professor Clem Tisdell was the Project Leader. Views expressed in these working papers are those of their authors and not necessarily of any of the organisations associated with the Project. They should not be reproduced in whole or in part without the written permission of the Project Leader. It is planned to publish contributions to this series over the next few years.

Research for ACIAR project 40, *Economic Impact and Rural Adjustments to Nature Conservation (Biodiversity) Programmes: A Case Study of Xishuangbanna Dai Autonomous Prefecture, Yunnan, China* was sponsored by the Australian Centre for International Agricultural Research (ACIAR), GPO Box 1571, Canberra, ACT, 2601, Australia.

The research for ACIAR project 40 has led in part, to the research being carried out in this current series.

For more information write to Emeritus Professor Clem Tisdell, School of Economics, University of Queensland, Brisbane 4072, Australia.

Global Warming and the Future of Pacific Island Countries

ABSTRACT

This article briefly outlines the cause of global warming, its trends and consequences as indicated by the International Panel on Climate Change. Sea-level rise is one consequence of particular concern to Pacific island states. It also reviews the views of economists about connections between economic growth and global warming. Whereas the majority of economists did not foresee a conflict between economic growth and global warming, the possibility of such a conflict is now more widely recognized following the Stern Report. International efforts, such as through the Kyoto Protocol, to reduce greenhouse gas emissions and their atmospheric concentration are discussed and prospects for post-Kyoto policies are considered. It is predicted that a significant reduction in global greenhouse gas emissions is unlikely to be achieved in the foreseeable future due to conflicting national interest (a prisoners' dilemma problem) and because it will take time to develop new technologies which will reduce greenhouse gas emissions. However, payment for greenhouse gas emissions (for example, via tradable permits) will accelerate desirable technological advance. Both international political action and efforts to develop and use technologies that lower greenhouse gas emissions need to be pursued. Given current and likely increases in greenhouse gas emissions, continuing global warming in this century appears to be inevitable and consequently Pacific island states will be adversely affected by sea-level rise and climate change. How they will be affected and to what extent is discussed together with their ability to cope with the emerging problem. Ways are also examined of addressing the consequences for Pacific island states of global warming.

Keywords: climate change; environmental Kuznets curve; global warming; Kyoto Protocol; Pacific islands; post Kyoto; sea-level rise; small island developing states; Stern Report.

Global Warming and the Future of Pacific Island Countries

1. Introduction

Human beings have been slow in recognizing the global environmental dangers of economic growth based on the use of carbon fuels and to take actions to avert these dangers. Since the Industrial Revolution, there has been increasing use of carbon fuels, first timber and other biomass, then coal, oil and subsequently natural gas. This process has added substantially to levels of greenhouse gases, particularly carbon dioxide, CO₂, in the Earth's atmosphere. This process is reducing radiation of heat from the Earth and is raising the average levels of temperatures on the Earth. Furthermore, significant increases in sea level are expected in this century, a process that has already begun.

Over very long periods of time, there have been natural variations in the average temperature on Earth and considerable variations in sea levels. What is peculiar about the current episode of the Earth's warming is that it is a consequence of human economic activity and it is occurring at speed which has never before occurred naturally. Therefore, it can be expected to cause serious disruption of existing biophysical systems in a relatively short period of time (with this century) and have adverse socio-economic consequences in most parts of the Earth. Naturally, low-lying areas near the sea (such as parts of Bangladesh and Egypt and low-lying atoll countries such as Kiribati and Tuvalu in the Pacific) will suffer greatly from the inundation which is predicted. However, this is just one aspect of the consequences for Pacific Island and other countries of global warming.

This article briefly outlines the cause of global warming, trends in the process and its predicted consequences, reviews views of economists about economic growth and global warming, and outlines global political developments that have been set in train by the occurrence of global warming. It then focuses on the major impacts which

global warming can be anticipated to have on Pacific island nations and policies that may be adopted to help address these problems.

2. Global Warming – Causes, Trends and Predicted Consequences

Sunlight falling on land and water heats the surface of the Earth and some of this heat is re-emitted as imposed radiation. Greenhouse gases absorb some of this radiation, warms the atmosphere and return some of this heat to the Earth's surface. The greater the concentration of greenhouse gases in the atmosphere, the larger is the heating effect.

CO₂ is one of the major greenhouse gases. Since the Industrial Revolution it has increased from 230 ppm in the Earth's atmosphere to 380 ppm and is now at levels that are much higher than have been recorded in the last 650,000 years (Pachauri, 2007). Even if CO₂ emissions are held at current levels, the concentration of CO₂ in the atmosphere will increase to around 525 ppm by the end of this century and global warming will accelerate in the not too distant future.

In the last century, global warming of about 1°C on average occurred. Stabilization of CO₂ emissions at the current level appears as though it could involve a global mean temperature increase of about 2.8°C and this will have very serious global environmental repercussions. On a global scale, there is probably little prospect of greenhouse gas emissions being reduced below current levels. They may continue to increase. Carbon emissions have risen at approximately a constant rate in the last 50 years, and although the rate of increase may be reduced as a result of a post-Kyoto global agreement, it seems too optimistic to predict an actual reduction in carbon emissions compared to those at present.

As a result, sea levels can be expected to continue to rise. They rose on average by about 10-20cm in the last century (Pachauri, 2007) and are expected to rise by between 9 and 88cm by 2100 compared to 1990 according to IPCC projections. However, the impacts are uncertain and a rise of more than 88cm is possible. Thus

sea-level rise is predicted to accelerate. Snow cover and glacier mass balance is declining globally and contributing to increases in sea levels (Pachauri, 2007). As a result of global warming, geographical patterns of water availability will change drastically, weather disturbances or disasters will become more frequent, global food availability could decline, human habitation will become more precarious due to storms, rising sea levels and adverse weather conditions, new health risks will emerge in more geographical locations (for example, malaria could become more widespread) and considerable loss of biodiversity and ecosystems is anticipated (National Geographic, 2007, 232(4), Map Supplement: Changing Climate). While one cannot predict all the consequences of global warming with certainty, there is growing consensus amongst scientists about the major consequences of global warming and its causes. There is no doubt that many Pacific island nations will suffer adversely from global warming and that sea-level rise will threaten the continuing existence of some.

3. Views of Economists about Economic Growth, the Environment and Particularly Global Warming

Mainstream economists have been tardy in accepting the possibility that continuing economic growth can have adverse environmental consequences. Responses to this possibility have been twofold. Several economic theorists have developed economic growth models that *ignore* any connections between economic growth and the environment, for example, Solow (1956, 1957) and Romer, (1994) as discussed for instance in Tisdell (2003, Ch.6). Other economists have argued that there is not necessarily any conflict between economic growth and the state of the environment, or that if there is conflict, it is short-lived and that sustained economic growth will eventually result in an improved environment. For the latter group continuing economic growth is the key to improving environmental conditions in the long run.

The concept of an environmental Kuznets curve (showing an inverted-U relationship between pollution intensities and GDP per capita) seems to have been initially suggested by Grossman and Krueger (1991, 1995). It was also initially reinforced by supporting empirical evidence (for example, Selden and Song, 1994). Environmental

Kuznets curves indicate that for some pollutants, such as CO₂, their intensity (for example, their level of emission in relation to GDP) rises at first with economic growth and then declines. Therefore, some economists have come to believe that greenhouse gas emissions (and environmental pollution generally) will not be a problem if only sufficient economic growth can be obtained globally. However, this ignores the capacity of the environment to absorb the emission of greenhouse gases without long-term environmental consequence. It ignores the concept of spaceship Earth promoted by Kenneth Boulding (1966).

Shortcomings of the argument based on the environmental Kuznets curve that continuing economic growth is the key to an eventually better environment are set out in Tisdell (2001). It is pointed out, for example, that even if *intensities* of greenhouse gas emissions fall with economic growth, their total level of emission can continue to rise. Furthermore, depending on absorption rates, concentrations of greenhouse gases in the atmosphere can continue to rise, even if the emission rates fall to some extent. Again, environmental thresholds may be reached which trigger irreversible environmental processes long before the predicted favourable environmental consequences of economic growth can be realized. In addition, it is also possible that falling pollution intensities or total emissions in more developed countries could be achieved by their relocating production that is more polluting (for instance, contributes more intensely to greenhouse gas emissions) in less developed countries, such as China and India. However, globally this does not solve the environmental problem when the pollutants involved have global consequences as in the case of greenhouse gases.

Asafu-Adjaye (in press) studied the relationship between CO₂ emissions and GDP per capita in several Pacific island countries. He found that in some cases the relationship appeared to conform with the environmental Kuznets hypothesis but that overall the results were inconclusive. However, on a world scale, Pacific island countries are small contributors to greenhouse gas emissions. Possibly, a more important global consideration for some is deforestation and their policies on reforestation, (Hunt, 2004). Considerable deforestation has occurred in the Solomon Islands and Papua

New Guinea, for example, which means that carbon sequestration there has declined considerably.

One of the analytical economists who has criticized the use of the environmental Kuznets curve is Stern (1998). Its shortcomings have also been pointed out by Arrow et al. (1995), Ekins (1997) and Rothman (1997). More recently, Stern has produced the Stern Report on the economics of climate change for the UK Government (HM Treasury, 2006). This report asserts that greenhouse gas “emissions have been, and continue to be driven by economic growth; yet stabilization of greenhouse gas concentration in the atmosphere is possible and consistent with continued growth” (HM Treasury, 2006, p.xi). Stern does not believe that a rapid and large reduction in global greenhouse gas emissions can be achieved but considers that stabilisation of CO₂ equivalents at around 550 ppm in the atmosphere is achievable if CO₂ emissions peak in 10-20 years time and if they are then reduced by 1-3% per year. While this result involves reduced growth of current GDP, the sacrifice in this growth will be much less than the future reductions in GDP growth if inaction prevails. In his view, current sacrifices of economic growth will avert much greater losses of growth in the future and should be made. However, even if Stern’s plan is adopted, increased global warming will occur. The extent of this increase is expected eventually to be in the range of about 1.5°C to over 5°C compared to pre-industrial times. This suggests that global warming of about 3.25°C is quite likely even if Stern’s relatively modest plan is adopted.

Note that none of the above discussion implies that economic growth and environmental deterioration must go hand in hand. Changing technologies could, for example, make it possible for some economic growth to continue without there being an increase in greenhouse gas emissions. The pricing of carbon emissions, for example, via carbon trading schemes, would provide an economic incentive for the development and installation of this technology. This will, however, take time to have effect, will depend on how quickly and widely charges are imposed on greenhouse gas emissions. To what extent and how quickly will the USA, China, India and Australia, for example, participate in a scheme to cut greenhouse gas emissions by

imposing charges on these, for instance by the use of carbon trading scheme? This will depend on the results of global political bargaining which will be complicated by clashes of self-interest between nations and their power struggles.

4. Global Political Considerations and Developments Relating to Global Warming

Mounting concern about climate change has been reflected in a number of international political developments since the beginning of the 1990s. In March 1994, The United Nations Framework Convention on Climate Change (UNFCCC) came into force. Most countries are signatories to this convention. It “recognized that the climate system is a shared resource whose stability can be affected by industrial and other emissions of carbon dioxide and other gases Under the Convention governments:

- Gather and share information on greenhouse gas emissions, national policies and best practices
- Launch national strategies for addressing greenhouse gas emissions and adapting to expected impacts, including the provision of financial and technological support to developing countries
- Cooperate in preparing for adaptation to the impacts of climate change”

(The United Nations Framework Convention on Climate Change, no date).

UNFCCC in itself only provides a mechanism for international consultation, a means for the gathering of information about climate change and an avenue for expressing concerns about climate change. It imposes no obligation on the signatories to the convention to reduce their greenhouse gas emissions. Nevertheless, it provided a platform for the formulation of the Kyoto Protocol which does impose mandatory

restrictions on the level of emissions of greenhouse gases by those countries which ratify it.

The Kyoto Protocol to the UNFCCC was negotiated in Kyoto in 1997 and came into force in early 2005 following its ratification by Russia. It has not yet (November 2007) been ratified by the USA (a major or the major international emitter of greenhouse gases) and by Australia (one of the highest per capita emitters of greenhouse gases in the world). Currently the signatories account for around two-thirds of greenhouse gas emissions globally (Anon, no date).

Those countries ratifying the Kyoto Protocol commit themselves to meeting their agreed greenhouse gas targets during the period 2008-2012. These targets vary between countries and are related to the 1990 level of emissions. More developed countries (Annex I nations) commit themselves on average to a reduction in their greenhouse gas emissions of over 5 per cent in the period 2008-2012 compared to their 1990 levels of emission and non-Annex I economies (mainly the developing countries) have no restrictions placed on their emissions of greenhouse gases.

The facility exists for carbon trading between nations that have ratified the Kyoto Protocol. For example, Annex I nations that do not intend to use all their carbon emission entitlements in the period 2008-2012 may sell these entitlements to other Annex I nations that want to use more than their entitlements. Thus, a mechanism for international exchange of greenhouse gases emission entitlements has been established. This provides for some flexibility but preserves the overall target for reducing greenhouse gas emissions by Annex I countries in the compliance period. Penalties have been specified for non-compliance by those nations ratifying the Protocol. How easy it will be to impose these penalties and how rigorously they will be imposed is still unclear.

Apart from purchasing carbon credits from other Annex I partners to the Kyoto Protocol, another mechanism exists for nations to reach their targets without reducing

their emissions of greenhouse gases to their agreed levels. This involves use of the Clean Development Mechanism (CDM).

The Clean Development Mechanism enables Annex I countries to obtain extra carbon credits by investing in projects in non-Annex I nations intended to reduce the levels of greenhouse gases in the atmosphere. Similar investments in projects in transitional economies in Eastern Europe and Russia may also qualify. However, the UN CDM Executive Board has to approve these projects. Projects which act as carbon sinks such as avoided deforestation and reforestation have been excluded as eligible projects, even though the original intention was to enable these to be eligible (Fearnside, 2006). This is unfortunate because according to Fearnside (2006, p.363) “avoided deforestation has by far the greatest potential both for climatic benefits and for achieving other environmental objectives such as the maintenance of biodiversity”.

Already international attention is turning to what will be done about global greenhouse gas emissions after 2012, the final year of the first commitment period of the Kyoto Protocol. In June 2007, the G8 leaders agreed that global CO₂ emissions should be at least halved by 2050. This is, however, easier said than done. Strong pressure exists to include developing countries in the targeting of greenhouse gas emissions, particularly those with large growing economies such as China and India. Allowance for forests as carbon sinks are also likely to be included in any new agreement (Fearnside, 2006).

While some countries have been reducing their greenhouse gas emissions, others have been increasing theirs. As a result, greenhouse gas emissions continue to rise globally at a steady rate. Although they started from a smaller base, very high rates of increase in emissions have occurred in China and India. China has or is about to surpass the USA as the world's major emitter of greenhouse gases (Anon, no date). The extent to which China and India may agree to curb their growth in greenhouse gas emissions is unclear because compared to more developed countries their per capita emissions are very low. The prospects for significantly reducing global greenhouse gas emissions in the foreseeable future do not seem high. The best prospect (given the possible

international political responses) would seem to be for the development of technologies that reduce carbon emissions and which can do so at low cost compared to alternative technology. The development of this technology is likely to be stimulated in Annex I Kyoto Protocol countries by the pricing of greenhouse gas emission, for example, some schemes for trading carbon credits. It may also be stimulated by government subsidies for relevant R&D. In practice, a two pronged approach is needed: (1) continue to press for improved global agreements on greenhouse gas emissions and (2) adopt policy means that reduce the intensity of greenhouse gas emissions in relation to output by encouraging the development and use of appropriate technologies.

In its diplomatic efforts to reduce global warming, the international community faces a classic prisoner's dilemma problem (Tisdell and Hartley, 2008, Ch. 16). The self-interest of each nation individually is not to make an economic sacrifice to reduce its contribution to global warming, and to do this irrespective of whether other nations make such sacrifices. As a consequence, all collectively are likely to suffer. Furthermore, disputes about how sacrifices should be shared between nations can hamper collective agreement. For example, what sacrifice should be expected of the United States compared to China and India? Although China's level of emission of greenhouse gases is now comparable to that of the USA, its per capita level of emissions are much lower. Furthermore, a substantial amount of China's emissions is associated with its exports to more developed countries and foreign investment in China, for example in its car industry. Thus, it can be argued that the demands of more developed countries have contributed to the rapid rise in China's greenhouse gas emissions. It can be claimed that the moral responsibility for Chinese pollution must be shared between Chinese suppliers and foreign investors and buyers. China is not entirely to blame; if it is a question of blame.

Given the political conflicts mentioned and that technological advance takes time, it is unrealistic to expect a significant reduction in global emissions of greenhouse gases in the near future. Therefore, continuing global warming during this century seems inevitable, particularly given the lag between greenhouse gas emissions and the rise in

the temperature of the Earth's atmosphere and of its marine waters. The future of Pacific island nations needs to be considered in this context.

5. Expected Impacts on Pacific Island Countries of Global Warming

While all countries are going to be affected by climate changes, many small island developing states will be severely impacted by sea-level rise which IPCC scientists expect could be of the order of 0.88 of a metre in this century. The island states at particular risk are those located in low-lying atolls such as Tuvalu and Kiribati in the Pacific Ocean and the Maldives in the Indian Ocean. Their already small land mass may disappear or be severely reduced by sea level rise and by erosion due to storm surges and cyclones. Most or all of their habitable land space may be lost and their residents are likely to be forced to seek refuge in other countries.

While all Pacific island nations and territories will be adversely affected by sea-level rise, the extent and nature of its impact will vary with their geographical features. States consisting of atolls will lose most or all of their habitable land whereas those comprised mainly of high islands will be affected less (see Table 1).

Table 1: Geographical features of Pacific island countries and territories

| Country/Territory | Land area (sq km) | Population (2004 estimate) | Geographic type |
|--------------------------------|-------------------|----------------------------|-------------------------------------|
| American Samoa | 240 | 57,000 | High islands and atolls |
| Cook Islands | 180 | 19,000 | High islands and atolls |
| Federated States of Micronesia | 702 | 109,691 | High islands and atolls |
| Fiji | 18,376 | 840,000 | High islands and a few minor atolls |
| French Polynesia | 3,521 | 252,692 | High islands and atolls |
| Guam | 549 | 166,773 | High islands |
| Kiribati | 726 | 97,813 | Predominantly atolls |
| Marshall Islands | 720 | 61,218 | Atolls |
| Nauru | 21 | 13,287 | Raised coral island |
| New Caledonia | 19,060 | 221,943 (2007) | High main island and atolls |
| Niue | 258 | 2,166 | Raised coral island |
| Palau | 475 | 20,000 | High islands and atolls |
| Papua New Guinea | 461,690 | 5,771,947 | High islands and a few minor atolls |
| Solomon Islands | 29,785 | 465,793 219,246 | High islands and a few minor atolls |
| Tokelau | 12 | 1,500 | Atolls |
| Tonga | 696 | 101,982 | High islands |
| Tuvalu | 26 | 10,900 | Atolls |
| Vanuatu | 12,189 | 207,331 | High islands and a few atolls |
| Samoa | 2,934 | 183,746 | High islands |

Source: Based on Asafu-Adjaye (in press), Table 1 and CIA, World Fact Book – New Caledonia

Pacific states that may become uninhabitable as a result of sea-level rise are Kiribati, the Marshall Islands, Tokelau and Tuvalu. Where will their residents go? Tokelau is a New Zealand territory and the Marshall Islands are affiliated to the USA. Therefore, their residents may be able to migrate to New Zealand and the USA respectively. On the other hand, Kiribati and Tuvalu are independent nations and do not have similar international connections. So far (November 2007) the Australian Government led by Mr. Howard has been unsympathetic to the possibility of residents of these countries being allowed to migrate to Australia as environmental refugees. Whether or not

future Australian governments will continue to adopt this position is unclear. The number of residents who may need to migrate from these countries is relatively small. Therefore Australia could accommodate these environmental refugees with little difficulty.

Pacific island states that consist solely of sufficiently raised atolls or of high islands might have limited land loss due to a rise in sea levels. These include Samoa and Tonga. Some of their lower areas may, however, be lost as a result of rising sea levels. Furthermore, those Pacific states that include in their landforms high islands and some atolls on the face of it would seem to have scope to relocate persons displaced by sea level rise within their borders. This would include countries such as Fiji, Papua New Guinea, the Solomon Islands and Vanuatu.

However, the position is more complicated than this macroscopic view suggests. For example, in relation to Fiji, Tonga and Western Samoa, Mimura (1999, pp.138-139) points out that their population is concentrated on narrow, low-lying areas fringing the mountains along the coast. Even though the area of their main islands is large and their average elevation is high enough, their economic activities are mostly concentrated on the coast. "The capital of each of these 3 countries is situated on a large coastal area. Therefore, the effects of inundation and flooding are not small for them."

The IPCC (2005, p.14) states that a large part of Papua New Guinea (PNG) is subject to inundation. This presumably includes a large tract of land behind the Gulf of Papua. Thus, although PNG has a lot of very high land, it is vulnerable to loss of lowland as well as its atoll islands. Even when it is possible in principle for islanders displaced by sea-level rise to migrate to higher land within their state, this may not be practical. Communal land rights can form a barrier to such migration in the Pacific, the available high country may be of low productivity and new ways of living may have to be learnt by the environmental refugees.

Mimura (1999, p.139) observes that “the risk of inundation and flooding is further intensified by social factors. In recent years, many countries in the South Pacific have experienced the migration of people from outer islands to the capitals, and a sharp increase in the population of the low-lying coastal areas. Such migration is often associated with economic difficulties and the land-ownership system does not allow the migrants to buy new land in some countries. Therefore, people tend to live in very low and unsafe areas, such as a lagoon coast in Nuku’alofa, Tonga”.

In addition, much of the infrastructure (such as roads) on the high islands is located along their coastal strip. Much of this infrastructure is vulnerable to sea level rises.

The UNFCCC (2005, pp.17-23) lists several problems which it believes that small island developing states will experience as a result of climate change. These include (1) growing difficulties with water availability, (2) coastal erosion and loss of corals, (3) increasing food scarcity (4) considerable biodiversity loss (5) heightened threats to human settlements and infrastructure (6) the spread of tropical diseases, such as malaria as temperatures of island countries in cooler regions increase and (7) diminished economic opportunities for example, due to reduced tourism. Most tourism facilities in these countries are adjacent to the coast and vulnerable to sea-level rise and major weather disturbances.

In relation to human settlements and infrastructure in small island states, UNFCCC (2005, p.21) points out: “ In most SIDS [small island developing states], narrow coastal plains provide attractive locations for human settlements and a variety of infrastructure – social services, tourism facilities, airports, port facilities, roads and vital utilities – to support economic and social needs. With the projected rate of sea-level rise and changes in the patterns of extreme events such as storms and coastal flooding, these settlements and critical infrastructure will be at severe risk. In some countries, particularly low islands and micro-atolls, resettlement outside the national boundary may have to be considered. Implementing this could become extremely complicated, however, especially for densely populated coastal lowlands. In extreme circumstances, some atolls may be abandoned altogether, which could be socially and

culturally disruptive as well as resource-intensive and which may be well beyond what most of these atoll countries can afford.”

Although the water surface of the Pacific Ocean will increase due to sea-level rise, this does not necessarily mean that Pacific island nations will have more marine resources. Fishing communities dependent on coastal reefs and inshore fisheries may experience problems due to loss of reefs. Ocean currents may also alter as a result of global warming and this may change the migrating patterns of tuna. Some island nations could experience reduced stocks of tuna and lower royalty payments for access to them. Some such as Kiribati and Tuvalu may experience a reduction in their EEZ due to inundation of some islands. As mentioned by Mimura (1999, p.139), “even if small islands are not currently inhabited, inundation of such islands means a loss of territorial seas and a reduction in the extent of their exclusive economic zones”.

While the problems facing Pacific island states as a result of global warming seem to be most severe for low-lying atoll countries, even those with some high land are in a vulnerable position. Given their small size and the extent of poverty in most of these states, they are not well placed to cope with the problem. Therefore, let us consider how their problems and potential problems as a consequence of global warming can or should be addressed.

6. Addressing the Problems of Pacific Island States Resulting from Global Warming

Because of lag effects, the process of global warming and sea-level rise will continue for a considerable period of time even if global emissions of greenhouse gases are slashed now. While reduced emissions of these gases would moderate further sea-level rise and warming, it will not prevent it. While global reductions in greenhouse gas emissions would be in the interests of Pacific island states, as was argued above the prospects of large reductions in the foreseeable future seem to be low. Therefore, it seems almost certain that Pacific island states will have to cope with global warming and rising sea-levels.

It has been suggested that they should start adopting policies now which will mitigate the predicted impacts of climate change (Mimura, 1999). In other words they should adopt anticipatory measures and policies. This, however, is easier said than done. Such policies would include prohibition of settlement on low-lying land, a start on re-settlement of those on low-lying ground to higher ground, the drawing up of contingency plans for evacuation of residents of low-lying islands in case of inundation or natural disasters, and relocation of infrastructure to higher ground or the placing of new infrastructure on higher ground. However, for these countries that have no higher ground, such as atoll countries, these are mostly not options. Hunt (2004, p.348) emphasizes the importance of adopting policies to help conserve barrier reefs as a protection from storm surges which will pose greater risks with sea-level rise. He recommends cessation of mining of corals where this is occurring and policies to reduce polluted run-off from agriculture and settlements which damages corals.

Such policies also face other problems. Resettlement may be resisted. Relocating infrastructure can be costly. Considerable investment is required. Given the extent of poverty in the Pacific islands, many states will lack the capacity to implement these measures. Furthermore, even in more developed countries, measures of this type have not been adopted. Successful political action is often that which *responds* to a crisis, rather than takes measures to avoid or reduce its anticipated effects. Political action often tends to be reactive and myopic. Even in more developed countries, such as Australia and New Zealand, measures of the above mentioned type have not yet been taken nor do they appear to be on the agenda.

It appears that some Pacific island countries (for example, the atoll countries) only have limited scope to mitigate the anticipated impacts on them of global climate change. They may be able to adjust to some of the effects for a time but in the end they are likely to be swamped by sea-level rise and storm surges. They, therefore, need to develop migration strategies and several are trying to do so by placing political pressure on Australia and New Zealand to be more receptive to their plight

(Prasad, 2007). In addition, it is in the interest of all Pacific island states to press internationally for a reduction in greenhouse gas emissions.

Given their limited resources and capacity, it can be argued that small island developing states need more foreign aid from developed countries to help them adjust to climate changes. Unlike more developed countries and emerging economies (such as those of China and India), the Pacific islands have been very minor emitters of greenhouse gases. They are the victims of this effect rather than perpetrators of it. Therefore, they may feel that developed countries have a moral responsibility to help them cope with their problem.

The extent to which some developed countries will assist is, however, unclear. They have reduced their aid to Pacific island countries in recent times. Developed countries also will be adversely impacted by climate change and this may make them less inclined to help less developed states in economic and environmental difficulties. Australia, for example is already experiencing (2007) severe drought which is reducing its production of food and contributing to rising food prices. This weather pattern is widely believed to be a consequence of global warming. The economic situation of more developed countries could deteriorate as global warming accelerates.

Pacific island states will have a particular interest in any post-Kyoto agreement about policies to address climate change. If for example, the coverage of the Clean Development Mechanism, or its successor, is extended to include averted deforestation or afforestation, then a number of Melanesian states may be able to obtain foreign funds as a result. However, this will not assist atoll states which only have a small land area and one that is unsuitable for forestry. The potential economic benefits to developing states from a reformed clean development mechanism are likely to be very uneven because the mechanism is underpinned by exchange principles rather than gift principles. Thus developing nations that have little capacity to contribute to reduced greenhouse gas emissions or to the lowering of concentrations of these gases in the atmosphere (such as atoll countries) have little scope to obtain funding via a clean development mechanism. While the Pacific island

countries receive some foreign aid (mainly from UNDP) under the Pacific Islands Climate Change Assistance Programme to help conserve their natural capital, (Hunt, 2004, p.348) this is insufficient to address effectively the issues identified above.

7. Concluding Comments

The IPCC has predicted a rise in average global temperatures compared to 1990 by up to 5.8°C by the end of this century (Anon, no date, p.4). It is clear that significant global warming will still continue in this century even if action is taken post Kyoto to stabilize greenhouse gas emissions globally. Most economists have been slow to accept the gravity of the situation. Many felt that the environmental Kuznets relationship provided grounds for optimism, namely that continuing economic growth would provide the key to improving environmental quality eventually and to reducing greenhouse gas emissions. But as pointed out in this paper, and elsewhere, prognosis based on the environmental Kuznets curve have proven to be inadequate.

Despite the Kyoto Protocol, global emissions of greenhouse gases have continued to increase at a constant rate, in part because of the rapid growth of emerging economies such as that of China and of India, and the United States (a major emitter of greenhouse gases) has not ratified Kyoto and effectively curbed the growth in its emissions (Anon, no date). There seems to be little prospect of large reductions in greenhouse gas emissions globally in the near future. Even if emissions were to be held at current levels, considerable elevation in temperatures and rises in sea level are expected to occur in this century due to natural lags.

Consequently, this will have severe adverse environmental consequences for Pacific island states of the type outlined in this paper. Some may become uninhabitable due to inundation and to greater exposure to severe weather events. Others which have some high ground will experience considerable economic hardship and social disturbances as they adjust to climate change. The extent to which more developed countries will be able to and willing to assist them is unclear. Hopefully, their situation will be given sympathetic consideration when post-Kyoto policies to deal with climate change are

negotiated by the international community. There is also a need for more detailed assessments of the extent to which individual Pacific states are likely to be impacted by sea level rise, for example, a rise of almost one metre in sea level in this century.

8. References

Anon (no date), Kyoto Protocol, *Wikipedia, the free encyclopedia*.

http://en.wikipedia.org/wiki/kyoto_protocol (accessed 4/11/2007).

Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B-O., Levin, S., Maler, K-G., Perrings, C. and Pimentel, C. (1995), Economic growth, carrying capacity and the environment. *Science*, 268, 520-521.

Asafu-Adjaye, J. (in press), Environmental quality and economic growth. *South Pacific Studies*, Research Center for Pacific Islands, Kagostima University, Japan.

Boulding, K.E. (1966), The economics of the coming spaceship Earth. Pp.3-14 in H. Jarrett (ed.). *Environmental Quality in a Growing Economy*, John Hopkins Press, Baltimore, MD.

Ekins, P. (1997), The Kuznets curve for environment and economic growth: accessing the evidence. *Environment and Planning A*, 29, 805-830.

Fearnside, P.M. (2006), Mitigation of climate change in the Amazon. Pp. 353-375 in W.F. Laurance and C.A. Pered (eds.). *Emerging Threats to Tropical Forests*, The University Chicago, Chicago and London.

Grossman, G.M. and Krueger, A.B. (1991), Environmental Impacts of North American Free Trade Agreement. *National Bureau of Economic Research Working Paper*, No. 3914.

- Grossman, G.M. and Krueger, A.B. (1995), Economic Growth and the Environment. *Quarterly Journal of Economics*, 10(2) 353-377.
- H.M. Treasury (2006), Stern review on the Economics of Climate Change. http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm (accessed 8/12/2006).
- Hunt, C. (2004), Economic globalisation impacts on Pacific island environments and aid implications. Pp. 336-351 in C. Tisdell and R.K. Sen (eds.) *Economic Globalisation: Social Conflicts, Labour and Environmental Issues*, Edward Elgar, Cheltenham, UK and Northampton, MA, USA.
- McKibben, B. (2007), 'Carbon's new moth'. *National Geographic Magazine*, 212(4), 33-37.
- Mimura, N. (1999), Vulnerability of island countries in the South Pacific to sea level rise and climate change. *Climate Research*, 12, 137-143.
- National Geographic (2007), Changing climate. *National Geographic Magazine*, 212(4), map insert.
- Pachauri, R.K. (2007), The IPCC Fourth Assessment Working Group Reports: Key Findings. United Nations, New York, <http://www.ipcc.ch/> accessed 22/10/2007.
- Prasad, B.C. (2007), "Economic integration and labour mobility: Are Australia and New Zealand short-changing Pacific Island States?" Mimeo paper prepared for a public lecture at the University of Otago, Dunedin, New Zealand.
- Romer, P. (1994), The origins of indigenous growth theory. *Journal of Economic Perspective*, 3(1), 3-22.

- Rothman, D.S. (1998), Environmental Kuznets curve – real progress or passing the buck? A case for assumption-based approaches. *Ecological Economics*, 25, 177-194.
- Selden, T. and Song, D. (1994), Environmental quality and development: Is there a Kuznets curve for air pollution emissions? *Journal of Environmental Economics and Management*, 27, 147 or 62.
- Solow, R.M. (1956), A contribution to the theory of economic growth. *Quarterly Journal of Economics*, 70, 65-94.
- Solow, R.M. (1957), Technical change and the aggregate productions function. *Review of Economics and Statistics*, 39, 312-324.
- Stern, D.I. (1998), Progress on the environmental Kuznets curve? *Environment and Development Economics*, 3, 173-196.
- Tisdell, C.A. (2001), Globalisation and sustainability: Environmental Kuznets curve and WTO. *Ecological Economics*, 39, 185-196.
- Tisdell, C.A. (2003), *Ecological and Environmental Economics: Selected Issues and Policy Responses*, Edward Elgar, Cheltenham, UK and Northampton, MA, USA.
- United Nations Framework Convention on Climate Change (no date), Essential background. http://unfccc.int/essential_background/convention/items/2627.php
- UNFCCC (2005), Climate change: small island developing states. Climate Change Secretariat (UNFCCC), Bonn, Germany.

PREVIOUS WORKING PAPERS IN THE SERIES ECONOMICS, ECOLOGY AND ENVIRONMENT

For a list of working papers 1-100 in this series, visit the following website:
http://www.uq.edu.au/economics/PDF/Clem_Tisdell_WorkingPapers.pdf or see lists in papers 101-140

101. Knowledge and Willingness to Pay for the Conservation of Wildlife Species: Experimental Results Evaluating Australian Tropical Species, by Clem Tisdell and Clevo Wilson, May 2004.
102. Antarctic Tourists, Wildlife and the Environment: Attractions and Reactions to Antarctica, by Clem Tisdell, May 2004.
103. Birds in an Australian Rainforest: Their Attraction for Visitors and Visitors' Ecological Impacts, by Clem Tisdell and Clevo Wilson, May 2004.
104. Nature-Based Tourism and the Valuation of its Environmental Resources: Economic and Other Aspects by Clem Tisdell, May 2004.
105. Glow Worms as a Tourist Attraction in Springbrook National Park: Visitor Attitudes and Economic Issues, by Clem Tisdell, Clevo Wilson and David Merritt, July 2004.
106. Australian Tropical Reptile Species: Ecological Status, Public Valuation and Attitudes to their Conservation and Commercial Use, by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, August 2004.
107. Information and Wildlife Valuation: Experiments and Policy, by Clem Tisdell and Clevo Wilson, August 2004.
108. What are the Economic Prospects of Developing Aquaculture in Queensland to Supply the Low Price White Fillet Market? Lessons from the US Channel Catfish Industry, by Thorbjorn Lyster and Clem Tisdell, October 2004.
109. Comparative Public Support for Conserving Reptile Species is High: Australian Evidence and its Implications, by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, October 2004.
110. Dependence of public support for survival of wildlife species on their likeability by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, October 2004.
111. Dynamic Processes in Contingent Valuation: A Case Study Involving the Mahogany Glider by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, November 2004.
112. Economics, Wildlife Tourism and Conservation: Three Case Studies by Clem Tisdell and Clevo Wilson, November 2004.
113. What Role Does Knowledge of Wildlife Play in Providing Support for Species' Conservation by Clevo Wilson and Clem Tisdell, December 2004.

114. Public Support for Sustainable Commercial Harvesting of Wildlife: An Australian Case Study by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, December 2004.
115. Endangerment and Likeability of Wildlife Species: How Important are they for Proposed Payments for Conservation by Clem Tisdell, Hemanath Swarna Nantha and Clevo Wilson, December 2004.
116. How Knowledge Affects Payment to Conserve and Endangered Bird by Clevo Wilson and Clem Tisdell, February 2005.
117. Public Choice of Species for the Ark: Phylogenetic Similarity and Preferred Wildlife Species for Survival by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, March 2005.
118. Economic Incentives for Global Conservation of Wildlife: New International Policy Directions by Clem Tisdell, March 2005.
119. Resource Entitlements of Indigenous Minorities, Their Poverty and Conservation of Nature: Status of Australian Aborigines, Comparisons with India's Tribals, Theory and Changing Policies Globally by Clem Tisdell, March 2005.
120. Elephants and Polity in Ancient India as Exemplified by Kautilya's *Arthashastra* (Science of Polity) by Clem Tisdell, March 2005.
121. Sustainable Agriculture by Clem Tisdell, April 2005.
122. Dynamic Processes in the Contingent Valuation of an Endangered Mammal Species by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, April 2005.
123. Knowledge about a Species' Conservation Status and Funding for its Preservation: Analysis by Clem Tisdell, June 2005.
124. Public Valuation of and Attitudes towards the Conservation and Use of the Hawksbill Turtle: An Australian Case Study by Clem Tisdell, Hemanath Swarna Nantha and Clevo Wilson, June 2005.
125. Comparison of Funding and Demand for the Conservation of the Charismatic Koala with those for the Critically Endangered Wombat *Lasiorhinus krefftii* by Clem Tisdell and Hemanath Swarna Nantha, June 2005.
126. Management, Conservation and Farming of Saltwater Crocodiles: An Australian Case Study of Sustainable Commercial Use by Clem Tisdell and Hemanath Swarna Nantha, August 2005.
127. Public Attitudes to the Use of Wildlife by Aboriginal Australians: Marketing of Wildlife and its Conservation by Clem Tisdell and Hemanath Swarna Nantha, August 2005.
128. Linking Policies for Biodiversity Conservation with Advances in Behavioral Economics by Clem Tisdell, August 2005.

129. Knowledge about a Species' Conservation Status and Funding for its Preservation: Analysis by Clem Tisdell, August 2005.
130. A Report on the Management of Saltwater Crocodiles (*Crocodylus porosus*) in the Northern Territory: Results of a Survey of Pastoralists by Clem Tisdell, Clevo Wilson and Hemanath Swarna Nantha, September 2005.
131. Crocodile Farms and Management of Saltwater Crocodiles in Northern Territory: Results of a Survey of NT Crocodile Farmers Plus Analysis of Secondary Information by Clem Tisdell, September 2005.
132. The Environment and the Selection of Aquaculture Species and Systems: An Economic Analysis by Clem Tisdell, October 2005.
133. The History and Value of the Elephant in Sri Lankan Society by Ranjith Bandara and Clem Tisdell, November 2005.
134. Economics of Controlling Livestock Diseases: Basic Theory by Clem Tisdell, November 2006.
135. Poverty, Political Failure and the Use of Open Access Resources in Developing Countries by Clem Tisdell, November 2006.
136. Global Property Rights in Genetic Resources: An Economic Assessment by Clem Tisdell, November 2006.
137. Notes on the Economics of Fish Biodiversity: Linkages between Aquaculture and Fisheries by Clem Tisdell, November 2006.
138. Conservation of the Proboscis Monkey and the Orangutan in Borneo: Comparative Issues and Economic Considerations by Clem Tisdell and Hemanath Swarna Nantha, March 2007.
139. Economic Change and Environmental Issues: Policy Reforms and Concerns in Australian Agriculture, by Clem Tisdell, April 2007.
140. Institutional Economics and the Behaviour of Conservation Organizations: Implications for Biodiversity Conservation by Clem Tisdell, March 2007
141. Poverty, Policy Reforms for Resource-use and Economic Efficiency: Neglected Issues by Clem Tisdell, May 2007.
142. The State of the Environment and the Availability of Natural Resources by Clem Tisdell, May 2007.
143. Economics of Pearl Oyster Culture by Clem Tisdell and Bernard Poirine, July 2007.
144. The Economic Importance of Wildlife Conservation on the Otago Peninsula – 20 Years on by Clem Tisdell, November, 2007.

145. Valuing the Otago Peninsula: The Economic Benefits of Conservation by Clem Tisdell, November 2007.
146. Policy Choices about Agricultural Externalities and Sustainability: Diverse Approaches, Options and Issues by Clem Tisdell, November, 2007.