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Climate mitigation roadmap: assessing low carbon scenarios for Malaysia

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ABSTRACT

This study evaluates three proposals against the baseline scenario of existing practices to reduce climate damage in Malaysia using an 'Empirical Regional Downscaling Dynamic Integrated model of Climate and the Economy', which was deployed using a top-down disaggregation approach. This model took account of a temperature increase cap of 1.5°C, (which was defined at the Paris Declaration of 2015), reasonable changes in the macroeconomic variables, and the climate variables of carbon emission reduction, climate damage, carbon emission control, and carbon concentration that were estimated based on records of global warming climate factors and predicted climate targets over the period 2010–2110. The three proposals evaluated are Stern, Nordhaus, and Malaysia's Intended Nationally Determined Contribution (INDC) to COP21. The costs of climate damage under the prevailing scenario will reach MYR40,128 (US$ 11,631) billion. The commensurate climate damage costs of the Stern and Nordhaus proposals will be MYR5,483 (US$ 1,589) billion and MYR6,068 (US$ 1,759) billion respectively. It will only be MYR5,264 (US$ 1526) billion under Malaysia's INDC of the COP21 regime. Thus, the most effective proposal for reducing climate damage in Malaysia over the period 2010–2110 is Malaysia's INDC to the COP21 proposal.

1. Introduction

The United Nations Conference of the Parties (COP) is a yearly conference held since 1995 under the framework of the United Nations Framework Convention on Climate Change (UNFCCC). It is the most important event whereby individual countries discuss national Government Climate Roadmaps (GCR) (UNFCCC, 2014). The Paris COP21 ended in 2015 with an agreement endorsed by delegates from 195 nations to decarbonise the global economy by capping temperature rise to 1.5°C over the next century (UNFCCC, 2015). This landmark agreement comes in the wake of mounting evidence about the dangers of global warming and climate change (Beckerman and Hepburn, 2007; Bonfils et al., 2008; JRC, 2013; Nordhaus, 2007; Weitzman, 2007).

The Intergovernmental Panel on Climate Change (IPCC) had argued that Earth could be 4.8 °C warmer by 2100, which could see sea levels rising up to 82 cm (32 inches) (Al-Amin and Leal Filho, 2014; IPCC, 2011). Consequently, the scientific community has shifted its focus from debating the facts on atmospheric concentration, temperature increase and emissions, to efforts to mitigate climate damage (Nordhaus, 2008; Stern, 2007). The European Union (EU) had called for legally binding mitigation targets at the COP20 in Lima in 2014. However, developing countries have lagged behind environmentally sustainable thresholds to check temperature rise, and hence, have not managed to pursue sustainable development strategies effectively. Malaysia's previous planned reduction in carbon emissions prior to the Paris Declaration ranked 51st among the countries in the projected climate change performance index until 2040 (Table 1).

In light of these developments, this article seeks to analyse the potential consequences of two global and one national proposals against the baseline scenario of existing trends to check climate damage in Malaysia, i.e., Stern (2007), Nordhaus (2008), and Malaysia's Intended Nationally Determined Contribution (INDC) to UNFCCC (2015) proposals. The Stern (2007) proposal discusses the effects of global warming on the world economy, and how climate

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Table 1
Climate change performance index for newly industrialised countries.

Rank	Country	Score	Rank	Country	Score	Rank	Country	Score
15	Morocco	63.99	36	Brazil	55.53	48	Singapore	50.32
20	Mexico	61.50	38	Thailand	54.51	49	Algeria	49.92
26	Egypt	59.00	39	South Africa	54.04	51	Malaysia	47.06
30	India	57.16	41	Argentina	53.60	52	Taiwan	46.81
34	Indonesia	56.24	46	China	52.41	54	Turkey	46.47

Source: CCPI (2014).

damage can be mitigated using environmental and carbon taxes based on time preferences. The Nordhaus (2008) proposal discusses the conditions for designing a global agreement to mitigate climate change. This proposal discusses global warming as an externality with greater weight given to time preferences and discount rates than to carbon taxes. The Copenhagen Accord (2009) had discussed explicit pledges by all major economies but with no clear path towards a treaty to bind the commitments. The key elements of the Copenhagen Accord included an aspirational goal of limiting temperature cap to below 2^0 Celsius by 1990 level.

One hundred and ninety five countries finally signed the Paris Declaration to reduce carbon emissions at the COP 21 meeting in Paris. The Malaysian INDC proposal submitted to UNFCCC (2015) calls for a reduction in per capita carbon emissions by 45% by 2030 from the emissions intensity figure of 2005 with 35% coming directly from domestic initiatives, and the remaining 10% following climate finance, technology transfer and capacity building from the developed countries (UNFCCC, 2015).

In this paper we will simulate Malaysia's emissions in the three proposals and comparing them with the baseline scenario. In doing so, we take account of the national parameters of social time preference factor, total factor productivity (TFP), consumption per capita, savings rate, real rate of return, industrial emissions (mtCO2 per year), emissions intensity, output (net damages and abatement), climate damage (share in gross output), backstop technologies price per ton carbon, abatement cost, carbon price (per tCO2), social cost of carbon and emissions control rate.[1]

2. Materials and methods

This study deploys a long run assessment using a multidisciplinary framework that combines economics, earth science and ecological variables[2] to analyse the four scenarios. A long-run dynamic method using the 'Empirical Regional Downscaling Dynamic Integrated Model of Climate and the Economy (ERDDIMCE)' is used to prioritize the mitigation of climatic damage taking account of the 2015 Paris Declaration, which in the case of Malaysia is the INDC presented to UNFCCC (2015).[3] This model links climate factors of climate change, carbon cycle, climate damage and carbon emissions, which affect economic growth with the endogenous variables of population, capital stock, output, and fossil fuel stock. The exogenous variables in the model are technology and policy. The measurable units are the value of goods and services (including vulnerabilities) in current prices.[4]

The ERDDIMCE takes account of economic growth by considering national growth, capital stock, consumption, interest rate, technologies to mitigate related climate effects, and vulnerabilities to model growth and development in future. We have included "natural capital" as an additional capital stock in the model. Meanwhile the outcomes from the four proposals are analysed to estimate changes to economic welfare using different classifications (see Appendix 1). The climate change outcomes under the three proposals and the baseline scenario are projected over a 100 years to provide the scientific basis for the adoption of an action plan by Malaysia aimed at reducing climate damage.

2.1. Study area

Climate measurements used in this study were carried out in the East and West of Malaysia. All national climate data used comes from the towns of Kuching (Sarawak) and Kota Kinabalu (Sabah) in East Malaysia, and Kuantan (Pahang) and Petaling Jaya (Selangor) in West Malaysia of 1°25′ 0″N and 110°20′ 0″E, 5°58′50″N and 116°4′ 37″E, 3°48′ 0″N and 103°20′ 0″E and 3°5′ 0″N and 101°39′ 0″E respectively (Fig. 1). These towns are the most representative of Malaysian towns.

2.2. Adoption of empirical downscaling method

The scenario and appraisal used in this study follows closely the global model of Nordhaus (2008), which is adopted to observe the interaction between global warming, climate change and macroeconomic indicators (see Appendix 1). The downscaling method offers a range of reasonable climatic change outcomes over the period 2010 to 2110. This top-down modelling approach[5] focuses on the impact on Malaysia by taking account of likely climate outcomes by moving from a global to country-specific level.

The adopted techniques used a large national data set to predict the annual cycle of (a) regional temperatures and (b) large-scale circulation fields in East and West Malaysia. The predicted annual cycle is downscaled by considering (i) industrial emissions ($mTCO_2$ per year), (ii) output (net damages and abatement per annum), (iii) climate damage (fraction of gross output), (iv) carbon price (per tCO_2), (v) emissions control rate (total), (vi) social cost of carbon, and (vii) real rate of return. These estimations used the assumption that the neighbouring countries of Thailand, Singapore, Indonesia, Brunei and Philippines follow their INDCs submitted to UNFCCC (2015).

Measurement instruments are subsequently included in the yearly average circulation parameters as predictor variables, and yearly average temperature fluctuations with carbon concentrations as predicted variables so as to estimate changes. All large-scale predictor data used in this study were gathered from the climate change scenarios of Malaysia 2001–2090 produced by the Malaysian Meteorological Department (MMD) (MMD, 2009). National temperature variations were derived from historical records to project changes in large-scale variations by concentration of GHGs (280–927 parts per million (ppm)). However, some modifications were made to the data supplied by MMD to meet the scope of study. The annual cycle of local temperature adopted is based on latitude 1°25′ 0″N and 110°20′ 0″E, 5°58′50″N and 116°4′ 37″E, 3°48′ 0″N and 103°20′ 0″E and 3°5′ 0″N and 101°39′ 0″E, to capture

[1] Stern had argued succinctly that Lima 2014 should focus on acknowledging the dangers of unmitigated climate change and a discussion of the benefits of mitigating climate damage.

[2] This model is adapted from the global model of Nordhaus (2008) to determine country specific outcomes with regional considerations using the downscaling method.

[3] This model uses mathematical optimization with geometric algebraic modelling system (GAMS) programming.

[4] The 2010 prices are used as the baseline, and the conversion rate is US$1 = MYR3.45.

[5] The top-down approach indicates global change and then individual countries tackling climatic initiatives to disaggregate them to measure.