Estimating Impacts of Climate Change Policy on Land Use: An Agent Based Modeling Approach

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INTRODUCTION

• This paper uses the Agent-based Rural Land Use New Zealand model (ARLUNZ) to assess the implications of an agriculture GHG-emissions reduction policy on farm income, land use and the environment. It is based on the results of a baseline model developed with the New Zealand Forest and Agricultural Regional Model (NZFARM), an agro-environmental economics optimization model (Daigeneault et al., 2012; Greenpeace et al., 2011), to develop a realistic estimate of changes in agricultural output and farm management from implementing various land-based GHG mitigation practices.

• There are various ways to model economic and land use impacts of environmental policy, most of which involve stylized representations of policy impacts to create tractability. Additionally, the lack of tractability in how farmers respond to environmental policy, the way environmental mitigation techniques are transmitted through farmer networks, and the effect that both have on the resulting effectiveness of environmental policy are under examined in the literature.

• The incorporation of these micro-level perspectives of human behavior through an approach such as an agent-based model can provide a better understanding of how farm scale emissions, agricultural policies, and environmental outcomes change over the time horizon and across land use.

AGENT-BASED MODELLING

• Agent-based models (ABM) are a valued technique in representing disaggregated decision making. While some suggest agent-based models (sometimes known as multi-agent systems) are far superior to macro-economic models, there are some shortcomings due to the various agents that make up the system (Kollmayer and Piet 2000).

• LUCC models have been utilizing agent-based approaches to analyze the simulation and estimation of a variety of LUCC scenarios. The benefit for LUCC models in this approach is the ability to have a human decision making process, which is important for examining the role and interactions of the actors which drive LUCC.

• Agents are discrete entities which are defined in terms of both their attributes, behaviors and decision making. The selection of the rules (or agent) and how these rules interact is usually made by those who define the simulation and actions which affect the underlying system (Suzuki et al., 2005, 2006).

• It is claimed that agent-based models advance most disciplines it is applied to as it includes more information about behavior, infrastructure and timing than previous methods of modeling (Page 2008).

FARMER TYPOLOGIES

• Farmers are typically assumed to be one of the most important actors when looking at the land use and food land change. This is because they make decisions on their land which have a large impact on the environment, how their decisions are made, and how those decisions influence others.

• In relation to this research, the farmer agents in corporate information from other farmer agents who operate in the same sector or are similar in age mimicking the potential social interaction of the actors being rewarded for understandable and reproducible behavior.

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• Policy impacts: A GHG price of $37.50/tCO2e per ton CO2 equivalent emissions from agricultural output (2015) is applied in the NZE Emissions Trading Scheme.

• The set of GHG prices are applied to fossil fuel carbon sequestration payments. The Huatulco/Malpais catchment is the Cuba Basin region of New Zealand. South Island is used as a case study. This catchment is located in a region with a large and diverse set of land uses and agricultural enterprises.

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Table 1. Farmer Typologies

<table>
<thead>
<tr>
<th>Life Stage</th>
<th>Incumbent</th>
<th>Successor</th>
<th>Type of Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm life-stage 1</td>
<td>45-50 years</td>
<td>20-25 years</td>
<td>Consultation</td>
</tr>
<tr>
<td>Farm life-stage 2</td>
<td>50-55 years</td>
<td>25-30 years</td>
<td>Expansion</td>
</tr>
<tr>
<td>Farm life-stage 3</td>
<td>55-60 years</td>
<td>30-35 years</td>
<td>Transition</td>
</tr>
<tr>
<td>Farm life-stage 4</td>
<td>60-65 years</td>
<td>35-40 years</td>
<td>Retirement</td>
</tr>
</tbody>
</table>

SOCIAL AND GEOGRAPHIC NETWORKS

• When examining farmer’s social interactions from both a conceptual and theoretical perspective, it is obvious that the farmer’s networks are framed around social (usually with farmers who are similar to themselves), and geographical (farmers who are different but are close in proximity). Interactions.

• Building on these two types of networks further they relate to two types of weighting factors which enable their implementation within an agent-based model; endogenous and exogenous (Schmit & Rounsevell 2006, Jager et al. 2006).

• To incorporate these interactions and their associated weighting factors, we assumed that the farmer network is constructed on the basis of a combination of quality knowledge. They capture the transfer of information, a process of meaning, and the establishment of a potential opening of transactional interaction based on this information.

• In relation to this research, the farmer agents incorporate information from other farmer agents who operate in the same sector or are similar in age. The potential social interaction between farmers in the same sector or age group.

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BASELINE AND SCENARIO ANALYSIS

Table 2. Key Outputs and Relative Change From Baseline

<table>
<thead>
<tr>
<th>GHG Price</th>
<th>Farm Profit</th>
<th>GHG Emissions</th>
<th>CO2e Emission</th>
<th>To baseline (tCO2e)</th>
<th>F Olson (tCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$15/tCO2e</td>
<td>$1.4</td>
<td>$0.3</td>
<td>$0.7</td>
<td>$347</td>
<td>$1.1</td>
</tr>
<tr>
<td>$25/tCO2e</td>
<td>$1.4</td>
<td>$0.3</td>
<td>$0.7</td>
<td>$347</td>
<td>$1.1</td>
</tr>
<tr>
<td>$75/tCO2e</td>
<td>$1.4</td>
<td>$0.3</td>
<td>$0.7</td>
<td>$347</td>
<td>$1.1</td>
</tr>
<tr>
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ECONOMIC AND ENVIRONMENTAL IMPACTS

• Farm profits at catchment level could actually increase over the simulation period because payments for forest carbon sequestration more than offset costs to sheep and beef and dairy enterprises.

• Farmers would have to be willing to adopt new technologies to adapt to climate change and commodity price risk.

REFERENCES


