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Robin Matthews

Innocent Bakam

George Dyer

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Evaluating the impacts of REDD+ interventions on livelihoods, social equity and effectiveness

Robin Matthews, Innocent Bakam, George Dyer[1]
[1]*James Hutton Institute, Craigiebuckler, Aberdeen AB15 8QH, UK*
[1] *george.dyer@hutton.ac.uk; robin.matthews@hutton.ac.uk*

Abstract: Globally, deforestation and forest and peatland degradation account for around 15% of total anthropogenic greenhouse gas emissions. Reducing Emissions from Deforestation and Degradation (REDD+) could be a cost-effective way of reducing this figure. Discussion on REDD+ has focused largely on the institutional architectures required to channel international finance streams to individual countries, neglecting how these funds will be used at the national level to encourage behavioural change. For REDD+ to work, benefits must flow through a long chain of actors, from national, regional and local governments, industries and businesses, to farmer groups and indigenous communities. The factors influencing decision-making at the lowest level—households—need to be well understood in order to design effective REDD+ interventions. In this paper, we discuss preliminary results from two agent-based models (representing tropical highland and lowland localities) looking into the likely impacts of REDD+ initiatives on land-use choices and their implications for local livelihoods. Our findings suggest that REDD+ could have significant repercussions for food prices, rents and wages, benefiting large landowners living in urban areas, while disadvantaging village households, particularly the landless.

***Keywords**:* Agent-based modelling; Computable General Equilibrium modelling; deforestation; REDD+; tradeoffs; synergies

1 INTRODUCTION

Conversion of forests into agricultural land is a major source of greenhouse gas (GHG) emissions – currently, a gross figure of 13 million ha of forests are lost annually, with net losses, allowing for afforestation and reforestation, of about 5.2 million ha yr^{-1} (FAO, 2010). Deforestation and degradation together release an estimated 4.4 Gt CO_2 yr^{-1} into the atmosphere (van der Werf *et al.*, 2006), both through the burning of the forest biomass, and from the oxidation of carbon stored in the soil under the trees during cultivation and in peatlands under drainage. Degradation, defined as decrease of density or increase of disturbance in forest classes, may represent up to 20% of this loss (Putz *et al.*, 2008). Other GHGs, such as CH_4 and N_2O, may also be emitted during slash-and-burn and subsequent land use. This could represent between 10 and 20% of anthropogenic GHG emissions, greater than that from the whole global transport sector (Stern, 2007).

The concept of Reducing Emissions from Deforestation and Degradation (REDD), whereby developing countries which are deforesting receive compensation from international carbon finance for reducing their rates of deforestation below an agreed baseline, has been put forward as a way of reducing these emissions. The original concept of REDD, which was included in the Bali Action Plan in 2007, has now been expanded to REDD+, additionally taking into account sustainable management of forests, conservation, and enhancement of forest carbon stocks

(Houghton *et al.*, 2010). The focus is now on how emission reduction targets agreed at the national scale would be translated into incentives to reduce deforestation at the local scale. Social justice questions such as who will be the winners and losers, and how to avoid rewarding the culprits of deforestation while forest dwellers are evicted from their homes or forced to abandon their agricultural activities, all need to be addressed. Solutions are likely to be quite context-specific and to vary from one country to the next, but if they are ignored, the climate policy discussions may become divorced from reality.

In this paper, we consider some of these issues by using modelling approaches to help evaluate the likely impact of REDD+ mechanisms on the behaviour and wellbeing of individual actors, particularly at the lower end of the REDD+ benefit chain, i.e., landowners and the rural population.

2 REDD+ BENEFIT CHAIN DYNAMICS

The REDD+ benefit chain can be thought of as a flow of incentives from the national level to those at the ground level, and a flow of certified emission reductions in the opposite direction. Incentives need to be targeted at a number of actors at a number of levels in this chain – these potentially include national governments, subnational governments (e.g. regional, district, village), large-scale industries, local communities, businesses, farmer groups, indigenous peoples, and those with specialist functions such as independent verification of emission reductions, proof of additionality and avoidance of leakage, and those involved in provision of alternative livelihoods at a more local level. Most of these actors will be required to make REDD+ work, but they will also expect a share of the benefits, thereby contributing to the ‘transaction costs’ of the system.

Excessive appropriation of benefits from the REDD+ value chain on the part of any one of them will result in less benefits for the others, with the risk that emission reductions cannot be delivered, and any further flow of funds will dry up, so that everyone suffers. High costs of certification and verification, for example, are currently mostly benefiting international consulting firms, making the regulated carbon market an ‘exclusive’ mechanism. In a sense, the REDD+ value chain is a type of social dilemma exemplified by the Tragedy of the Commons (Hardin, 1968), in which there is a temptation for actors to maximise their own extraction of funds from the system, but if everyone does that, everyone potentially loses out. A high degree of cooperation between all actors, therefore, is necessary; corruption in particular must be safeguarded against. These issues have not been modelled in detail.

3 MODELLING LAND USE CHANGE AT THE FOREST MARGINS

While there is a wide gamut of approaches to studying land use change, it is useful to distinguish those that explicitly model agents’ behaviour (e.g. Kindermann *et al.*, 2008) from those that do not (e.g. Soares-Filho *et al.*, 2006). Among the former, general equilibrium (CGE) models, for example, describe the functioning of an entire economy, which is defined by the determination of various prices and output simultaneously (Gurgel *et al.*, 2007; Hertel *et al.*, 2009) and have been widely used in policy design and analysis. Most CGE models are generally highly aggregated, where, for example, agricultural producers are represented by a single agent that maximizes aggregate profit, which neglects both the heterogeneity of individual producers’ decisions and the interactions between them. This may not matter so much where relatively homogeneous industrialized agriculture is the rule (Gurgel *et al.*, 2007), but interactions among individual economic agents can shape outcomes in developing countries, where market imperfections and heterogeneity across producers are common (Dyer & Taylor, 2011). In the context of REDD+, these interactions can determine potential initiatives' repercussions on land-use and equity issues relating to local livelihoods.

An alternative to aggregated CGE simulation models is agent-based models (ABMs), which analyse human interactions using a bottom-up approach (Matthews *et al.*, 2007). These models can incorporate social and non-monetary factors and reproduce the non-linearities ('tipping points') often observed in coupled systems (Matthews *et al.*, 2007). ABMs have been linked to biophysical models (e.g. soil carbon dynamics) to investigate coupled human-environment interactions (Matthews, 2006) and used to analyse land-use and deforestation (e.g. Manson & Evans, 2007). Such models often rely on heuristic rules, which are considered more realistic than the optimizing behaviour associated with prices and rents, and can also take into account the micro-variation between decision-making entities. For example, household-specific (shadow) prices and rents can determine who perceives and responds to a particular economic opportunity, which can lead to the reallocation of resources across sectors and farms after a shock (Dyer *et al.*, 2006). Aggregate CGE models overlook this reallocation, which can nevertheless influence REDD+'s impact on aggregate outputs, local livelihoods (including equity issues) and the potential for leakage. However, it is possible to incorporate both the principle of general equilibrium and heterogeneity across economic agents into a single model by recognizing that individual households constitute small economies where the output and shadow prices of subsistence activities are determined jointly (Dyer *et al.*, 2006). Individual household models can then be integrated into a model of a larger economy where producers and consumers interact, influencing aggregate supply and demand as well as land use.

Such a modelling approach provides greater detail and flexibility than alternative models, incorporating differences in prices, production technologies, and market participation across households and regions that can be vastly heterogeneous in terms of microeconomic behaviour (Dyer & Taylor, 2011). Decision rules of subsistence households can be elicited using stated-preference methods and then incorporated (in lieu of heuristic rules) into an optimization context (Dyer *et al.*, 2006). Since few households live at a level of physiological subsistence, subsistence production and consumption in the model respond to multiple variables, including households' changing value perceptions. These range from their appreciation of the value of agro-biodiversity to the social and cultural importance of farming as such. Rather than substituting optimizing behaviour, such perceptions influence household's ubiquitous responses to market signals (Dyer *et al.*, 2006). At the same time, disaggregate models of this sort can be as reliable as aggregate macroeconomic models, particularly in a developing context (Brooks *et al.*, 2008; Dyer & Taylor, 2011). They also offer distinct advantages, including the possibility of reconciling micro- and macroeconomic explanations of aggregate processes, which provides an avenue to validate the model (Robinson *et al.*, 2007). This reconciliation is possible because, in the model, macroeconomic behaviour is the result of individual decision-making (Dyer & Taylor, 2011). Another advantage is their ability to address equity issues by identifying winners and losers at a fine scale, while yielding a more thorough understanding of the economic processes involved, and thus a more suitable basis for policy design and analysis.

4 ASSESSING THE LOCAL IMPACT OF REDD+ INTERVENTIONS

We use an agent-based model in a general equilibrium context to analyse some of the implications of a voluntary Payments for Environmental Services (PES) Programme that sets aside a fraction of arable land for reforestation. The model is based on household survey data from a highland village and represents the various agents interacting within its economy.

Each household in the sample (i.e., 49 households) is modelled as an independent agent (i.e., that engages in various economic activities, including on-farm activities and the sale of wage labour) that nevertheless interacts with other agents in the economy. Individual households can fall into different (albeit non-exclusive) agent types depending on various factors, including their characteristics, productive activities and interactions with other agents. Among the first is land ownership, which distinguishes landholders from landless households. According to survey data, 96% of households in the locality own arable land. The average land holding is only 0.4 hectares, but endowments vary widely (s.d. = 0.50). The distribution of land is highly uneven: 2% of households own 19% of the land.

Households' activities include cropping: 98% of local households cultivate the land to grow a multi-crop system based on maize. Around 37% of arable land is rented, which entails two types of agents: landlords and their tenants. Two thirds of landless households—i.e., 4% of the local households—grow corn and thus must rent land from others; but an additional 35% of landowners also rent land in to complement their own endowments. Almost 20% of rented land is supplied by local landlords; the rest—i.e., 30% of the land in the locality—is owned and rented out by absentee landowners, who live in urban areas but own land within village boundaries.

Agents also interact through exchanges in maize and labour markets. Labour markets entail the presence of employers (48% of households and absentee landowners) and employees/farm workers (48%); while participation in maize markets distinguishes commercial (or surplus) producers (4% of households) from subsistence farmers and non-farmers. Interaction with the programme administrator further defines households as either PES participants or non-participants. We have used the model before under alternative sets of assumptions to analyse the implications of two broad themes: a) the local context and b) programme design. Here we focus on the latter.

In our model economy, the programme considered has both direct and indirect repercussions on different types of agent (i.e., segments of society). Setting land aside affects agricultural output directly, while payments have a direct effect on participating landowners' income. Participants are more than compensated for their opportunity costs, but the programme has additional, indirect repercussions for participants and non-participants alike. As the injection of cash circulates across productive sectors, payments have a positive multiplier effect on the economy. However, multiplier effects can also be negative. According to our estimates, setting aside 10% of land could ultimately generate losses for the community as a whole and even for most participants with the exception of large landowners. Costs and benefits depend on the way in which participants adjust to the programme's requirements and non-participants respond to these changes.

Authorities might consider expanding the programme as a way to increase participation and improve the distribution of costs and benefits. Our results suggest, nevertheless, that expanding the program from 10 to 20% of the total land area can increase the net costs to non-participants as well as the average participant (Fig. 1).

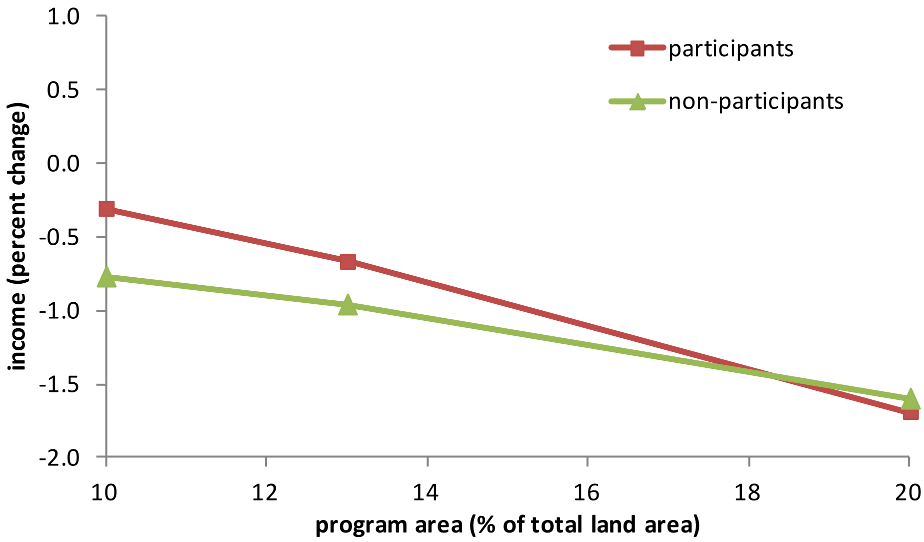

Fig. 1. Effects of programme area on village incomes

The reason is that local participation is constrained by households' demand for subsistence goods (i.e., staple crops). As a result, it is mostly absentee landowners that enrolment more land into PES. Given that they also act as landlords, absentee landowners benefit additionally from increases in land rental rates. Unlike villagers, landlords are not hurt by decreasing wage rates. Overall, absentee landlords are able to appropriate the programme's benefits without assuming any of its costs, which could be substantial (Fig. 2).

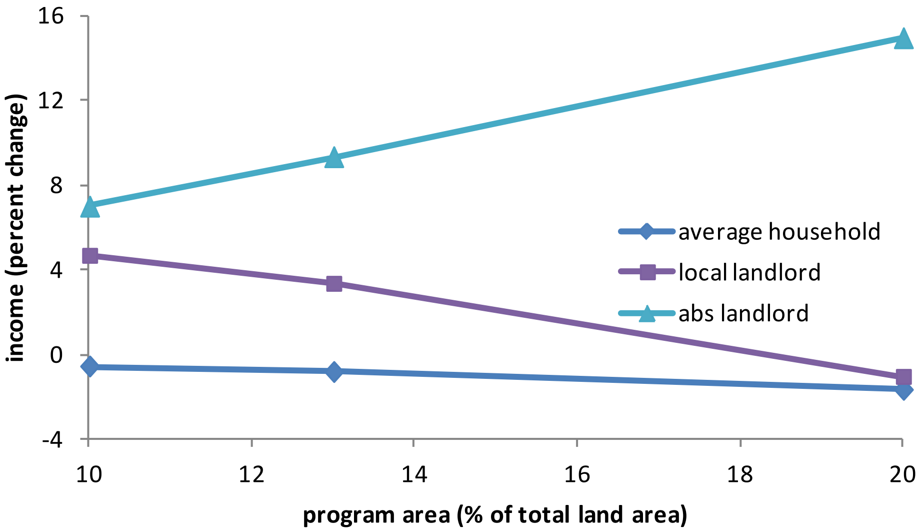

Fig. 2. Effects of programme area on local and absentee landowners' income

In a parallel study, an agent-based approach is being used to investigate the impacts of agricultural intensification as a REDD+ mechanism to reduce the rate of deforestation, with a particular focus on cooperation among farmers, peer pressure, reluctance to change, and trust in the authorities responsible for setting up the scheme and delivering REDD+ benefits to farmers. The concept of agricultural intensification as a means to reduce tropical deforestation was first put forward by Borlaug (1983), one of the fathers of the Green Revolution, who argued that by increasing food production from a given amount of land, the need to clear forest for this production is reduced. Whether this is what happens in reality is the subject of some controversy. In an open system where output prices are unaffected by local production, intensification increases the returns from existing cropland,

and, in turn, provides an incentive for farmers to clear more land. If, on the other hand, growth in productivity causes a decrease in food prices, expansion of agricultural land is disincentivized. Localized increased productivity may also attract more people to migrate into the area, resulting in further clearing of the forest.

To investigate this, we have assumed three types of agents in the model – Households, Village Councils and the Government. Households make decisions on land use allocation according to their needs (subsistence, school fees, health expenses and expenses for special events) and their willingness to cooperate with other households in the village in achieving the village's avoided deforestation goals. Households cultivate a mixture of crops for subsistence, and obtain cash income from selling cocoa, coffee and plantain. Each Household agent follows three (contrasting) goals—addressing the household subsistence needs, addressing cash needs, and contributing to avoiding deforestation. Subsistence needs have the highest priority and depend on the size and composition of the household. Surplus production is sold and revenues contribute to the expenses of the household, which include school fees, health expenses, and organising special events such as wedding or funerals.

The Village Council agents share out the benefits of the REDD+ scheme. Households in a village have access to the same market and share the same forest area. Villages differ in their land fertility, the availability of forest, and the prices of goods in the local market. In order to benefit from the REDD+ scheme, the Village Council has to ensure at least a set area of avoided deforestation. When a Village is eligible to compensation for saving forest, its Households receive subsidised fertiliser from the Government, depending on the area of avoided deforestation above a set threshold. The Government agent receives REDD+ funds on the basis of avoided deforestation achieved at the national level, keeps a set percentage to cover administration costs, and uses the remaining funds to subsidise fertilisers in Villages which are eligible for compensation. The Government agent also carries out Monitoring, Reporting and Verification (MRV) activities.

Surveys were carried out in eleven villages to gather data to parameterise the model. The model is initialised with the creation of 286 agents representing the households in the survey, eleven agents representing the villages, and a government agent. Each household is allocated fields corresponding to their current land endowment. Fields are characterised with their current state or usage (mixed-food crops, plantain, cocoa/coffee or fallow) and their age in the current state. As fallows get older and reach a certain age, they are abandoned and revert to forest with ownership being transferred to the village. Two scenarios are being considered: a Business As Usual (BAU) scenario and a REDD+ scheme scenario.

In the BAU scenario, a Household decides to clear forest or an old fallow when the expected outputs from its currently cultivated fields do not cover its needs. Production from cultivated fields decreases each year, and soil fertility is progressively restored as fields are abandoned in fallow. The BAU scenario is used to estimate the level of expected deforestation which is then used as a baseline to estimate the area of avoided deforestation when the REDD+ scheme is introduced. In the REDD+ scenario, Households take into account the expected output from fertiliser-intensified cropping when making the decision to create new farms. However, the incentive is based on the aggregated outcome of their decisions at the village level.

Analysis of the data indicated that 71% of households were planning to continue deforestation at least at current rate. Only 23% considered that subsidising fertilisers and other agricultural machinery would influence their decision to continue deforestation or not, whereas 68% rated direct cash payments to households as the most convincing incentive. However, it is not clear whether a

REDD+ scheme rewarding each household directly would be effective and efficient, as non-participating households would still have access to the forest as it belongs to the village as a whole. It could be expected that intensification would help households in addressing the needs for subsistence crops while extending cropping cycles of mixed crop farms. Longer cropping cycles on currently cultivated fields would reduce the need of clearing forest or old fallows to establish new farms. A range of simulations are being conducted to identify the conditions under which a REDD+ scheme based on intensification could lead to effective and efficient avoided deforestation.

5 CONCLUSIONS AND RECOMMENDATIONS

No single model can cover the whole REDD+ benefit chain or the range of possible behavioural issues involved in land-use change. However, combining general equilibrium modelling and agent-based modelling is a promising approach to incorporate individual decision-making to evaluate the impact of particular REDD+ interventions at the whole economy/whole landscape scale, allowing assessment of their effectiveness, efficiency and fairness at the local level. Such models can take into account the micro-variation between decision-making entities and how these respond differently to REDD+ interventions which can lead to the reallocation of resources across sectors and farms. Aggregate models overlook this reallocation, even though it can be significant in terms of aggregate outputs, local livelihoods (including equity issues) and the potential for leakage. Results presented in this paper, for example, indicate that a REDD+ programme paying for land to be taken out of production and returned to forest may only benefit landowners and actually be disadvantageous to the landless through its effect on food production and prices and local wage rates.

Obtaining data for such models, however, is a significant challenge, particularly in developing countries, requiring the adoption of modelling assumptions. These assumptions determine to a large extent the range of questions that can be addressed, as well as the realism of every modelling exercise. Further work is therefore needed to assess the relative contributions of various modelling alternatives.

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