A CGE Analysis of a REDD scheme for Nepal

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Abstract: A dynamic computable general equilibrium (CGE) model of the Nepalese economy is used to analyse the effects of a REDD scheme.

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Future Rates of Deforestation and Degradation in Nepal
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The SAM database used by the CGE model was supplied by Dilli Raj Khanal (see Appendix B). Other useful data were received from: Basanta Gautam, Suk Won Choi, Dilli Raj Khanal and Rajesh Rai.

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1. Introduction

A REDD scheme exchanges payment, to a developing country, for a promise to reduce forest clearing and/or forest degradation. The payment and the restrictions on forest use will affect various sectors of the economy, and the effects will vary over time. Thus a multiperiod, multisectoral economic model is needed to flesh out these effects in detail. We describe below how a dynamic computable general equilibrium (CGE) model of Nepal can be used to evaluate the effects of a REDD scheme for Nepal.

The remainder of this paper is laid out as follows. Section 2 discusses REDD schemes and provides some background on forests in Nepal. Section 3 describes the CGE model and database used for the simulations. The base forecast (with no REDD scheme) is described in Section 4. Similarly Section 5 presents results from an alternate, policy forecast, which does include a REDD scheme. We conclude in Section 6.

2. Carbon taxes, REDD schemes and forests in Nepal

From 1880 until 2012 world temperatures rose[1] by 0.8°C. During the last 30 years a consensus has developed that this temperature rise (a) is largely due to CO_2 emissions caused by humans, and (b) may cause serious problems. The CO_2 damage, which affects all regions, is due to the accumulated level of atmospheric CO_2 (not the current emision rate) and may[2] persist for decades, even if emissions cease. The main emission sources are burning of fossil fuels and deforestation. Deforestation accounts for perhaps 6–17% of all emissions worldwide (Werf et al, 2009), and accounts for a much larger share of emissions in some countries. Deforestation emissions arise because a forest is a carbon store (even though a mature forest absorbs little net CO_2). Conversion of forest to, say, cropland, releases this carbon as CO_2.

To reduce atmospheric CO_2, emissions taxes have been proposed -- but not widely adopted. If applied uniformly, such taxes would raise enormous revenue -- most of it from richer countries. Politically acceptable schemes are usually far more limited in scope. For example:

- They may apply to one country only, or a group of countries.
- 'Grandfathering' arrangements may extempt from taxation emissions below a stipulated (often historical) level.
- Whole sectors, such as agriculture, may be exempt. Often export-oriented sectors are exempt.

A variation on the tax scheme is a payment ***not*** to pollute. For example, a poorer country may be paid to replace older, dirtier, power stations with more efficient modern generators. The payment would reflect the emissions saved by the upgrade.

REDD (Reducing Emissions from Deforestation in Developing countries) schemes fall within this category. First, the schemes focus on forests only. A country must establish a 'reference level' of forest-related emissions that do or might occur in the absence of a REDD payment. REDD payments will be made in proportion to the extent that future emissions fall below this reference level.

There are many practical difficulties with such schemes. Establishment of the reference levels, and subsequent emissions monitoring impose complex requirements. A basic REDD scheme does not reward previous progress in reducing deforestation or forest degradation. There is no payment for forest stewardship that merely maintains the status quo. Thus international discussions continue, which may result in agreement about modified REDD schemes.

Nevertheless this study focusses on a basic REDD scheme, where payments from abroad are in proportion to the reduction in emissions below a reference level. As explained below, we (a) focus only on the Terai/Churia part of Nepal; and (b) base the reference level on the average rate of deforestation during recent decades.

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[1] source: NASA-GISS Global mean land-ocean temperature

[2] Estimates of the half-life of atmospheric CO_2 range from 5 to 200 years (IPCC, 2001).

2.1. Forest use in Nepal[3]

Forest still covers much of the non-alpine regions of Nepal, although much has been cleared in the most cultivable plains areas. Many forests are owned and managed ultimately by the state; although management has been delegated in some places to the local level (see below). There is selective logging of old/mature trees but rather little active forest management (such as planting, thinning, and optimized timing of cutting). Often, the stock of trees is older than would be deemed optimal. Illegal logging also occurs.

As well as providing sawlogs, forests and their products support Nepalese agriculture and poorer people. Firewood, used for cooking and heating, is gathered from the ground, from low branches and from coppiced stumps, filling perhaps half of Nepal's energy needs. Much firewood gathering is illegal or uncontrolled. Forage for livestock is gathered similarly. Livestock may graze in the forest; their dung and litter from the forest floor are used to fertilize fields. All of these activities are often pursued above a sustainable level, leading to forest thinning and degradation.

2.2. The Hills region of Nepal

The Hills area of Nepal is shown in Figure 1. It has historically suffered from poor communications, poverty and over-population. Deforestation and forest degradation (caused by over-harvesting of firewood and fodder) are long-standing problems. Yet since the 1970s considerable progress has been made to combat these problems, especially through Community Forestry schemes, whereby local communities are encouraged to manage and protect local forest resources. Two Hills-specific factors underlying the success of such schemes are that (a) it is usually possible to associate particular forest areas with particular villages; and (b) villages tend to be fairly ethnically homogenous. These factors assist in creating and enforcing local forest management plans (which are embedded in wider schemes for community development). Deforestation and degradation have been slowed, and sometimes reversed. Another factor helping to preserve the Hills forests is outmigration to the Terai area (see next subsection).

The author was informed in Nepal that although the Community Forestry schemes were very successful, there was little scope to greatly expand the schemes. Consequently this study assumes that a REDD scheme will not affect Hills forest management. The good work of the past will continue, unrewarded by REDD, with 'reference level' emissions.

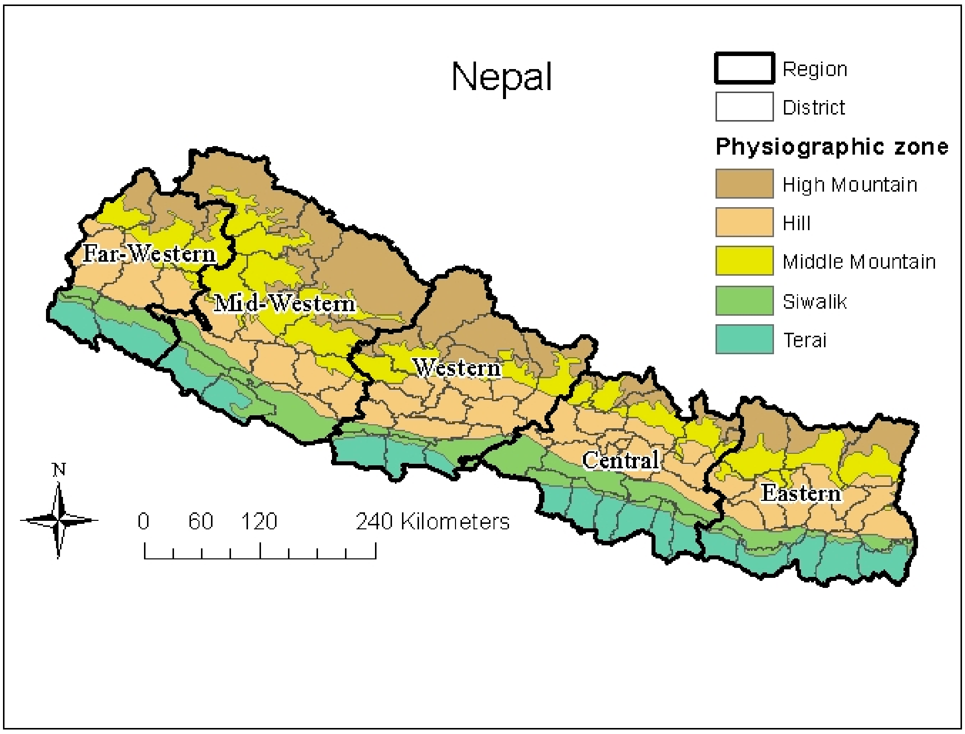

Figure 1. Regions of Nepal

[3] The brief survey in this and the next section draws on material found at the excelllent www.forestrynepal.org

2.3. The Terai/Churia region

While mostly hills and mountains, Nepal includes also a fertile low-lying plains region along its southern border, called the Terai. This, and the first range of foothills (called Churia or Siwalik) are shown green on the map above.

Originally the Terai/Churia region was mostly forest, with the iconic Sal tree as the dominant species. Infested by malaria, it was little populated, although export logging took place from the 1920s. In the 1950s malaria was eradicated using DDT. The government encouraged forest clearing and migration from the overcrowded hills. Migrants from India arrived too. Today much of the Terai forest has been converted to cropland, and deforestation continues. The Terai/Churia region now accounts for most of Nepal's agriculture and GDP, and about half the population.

Deforestation causes CO_2 emissions (see below) but the loss of the unique Terai/Churia habitat has equally raised international concerns.

For various reasons Community Forestry schemes have been less successful in the Terai than in the hills (Nagendra et. al., 2005). Better roads, the proximity of the Indian border, and the high value of Sal timber make it harder to protect against illegal logging. Compared to the hills, it is less easy to assign particular forest areas to particular communities, and local populations (often migrants from elsewhere) are more divided by ethnicity and caste. Finally, the greater fertility of the Terai increases the pressure to convert forests to cropland.

We estimate (see Appendix A) that during the last 20 years about 2617 hectares of forest in the Terai/Churia were annually converted into agricultural land, emitting each year 1041106 tonnes of CO_2. We simulate the effects of a complete cessation of this deforestation, together with the effects of the REDD reward.

2.4. Deforestation and degradation

Forest clearing causes emissions because the above-ground carbon content of forest is greater than than of the replacement use (eg, crops). Yet forest degradation is also noted as a cause of emissions. The degraded forest has fewer, smaller trees, and sequesters less carbon.

The calculations presented later in this paper ignore emissions from degradation; that is, they are assumed to be unchanged by a REDD scheme. We use Figure 2 to explain this assumption.

The top panel A of Figure 2 graphs the 2015 above ground carbon per hectare of the Terai/Churia, with the least-carbon land (crops) at the left, and the most-carbon land (healthy forest) at the right. In between is an area of degraded forest, with a range of carbon contents. We may imagine, as the diagram suggests, that the degraded forest forms a fringe between cropland and healthy forests. The area under the graph is the total amount of sequestered carbon (shown as zero for crops).

Panel B of Figure 2 shows the situation in 2045 with no REDD scheme. Crop area has increased, and forest area has fallen by the same amount. The area of (and carbon stored in) degraded forest does not change. So emissions can be estimated merely by measuring the change in forest area. In effect, the degraded forest fringe simply moves right over time.

To an observer on the ground, it could well appear as if degradation were the main cause of emissions. Imagine a forest resident who lived initially at the border between healthy and degraded forest (shown by a house symbol). Over the period 2015-45 he would see his forest surroundings steadily degraded by grazing, litter removal and excessive harvesting of firewood and forage -- all leading to emissions. There would be little above-ground carbon around his house in 2044 -- so that emissions from the final conversion to cropland might be small.

Panel C depicts an alternate scenario for 2045 -- where forest area has again shrunk, but crop area has not expanded. Instead, the area of degraded land has grown. This scenario is also possible, but is not simulated here.

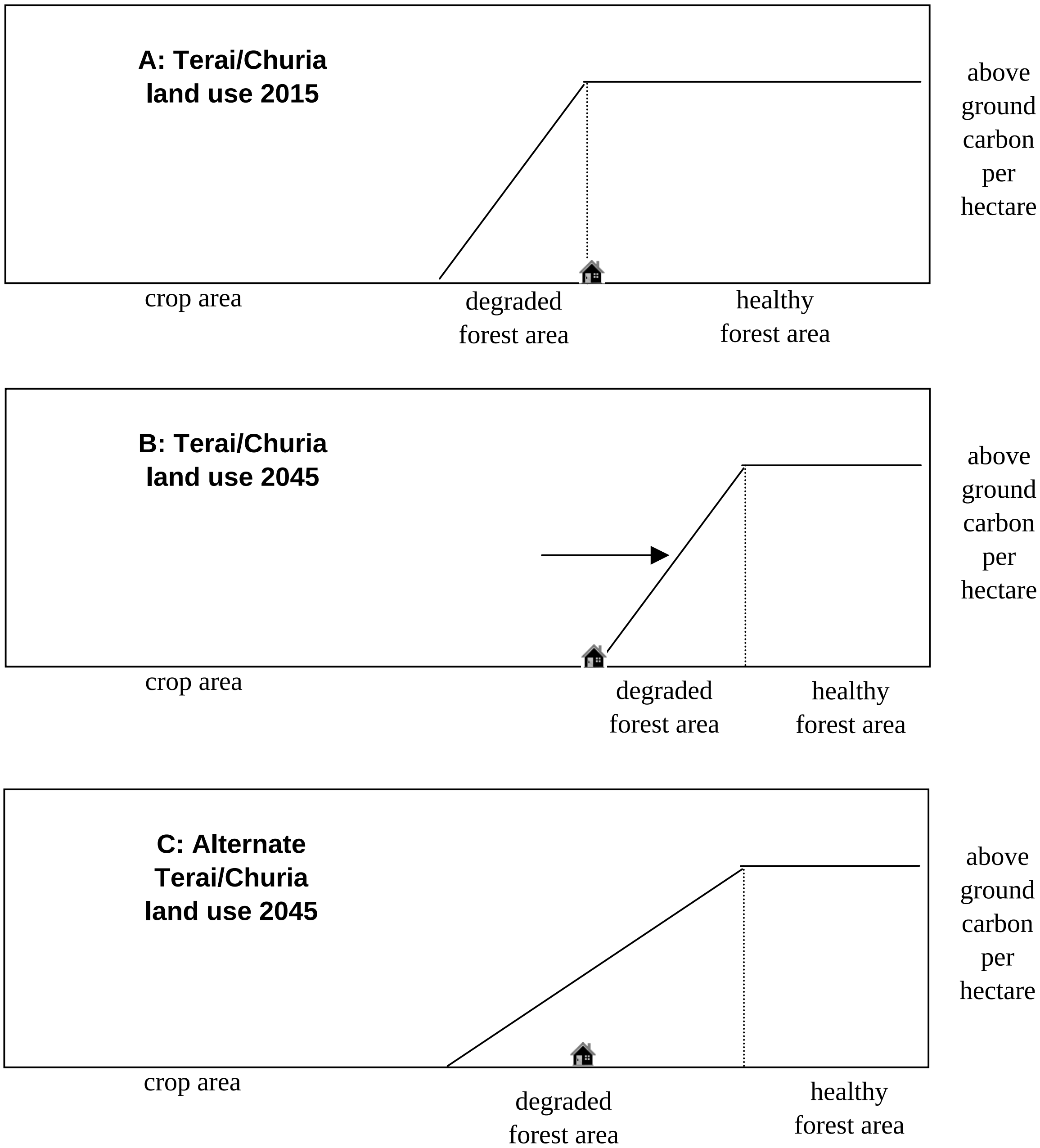

Figure 2. Deforestation and Degradation

In the REDD policy scenario presented below we assume that Terai deforestation ceases from 2015, so that Panel A also depicts the 2045 situation. Thus, each part of the fringe area must retain over time the same carbon content. By contrast, in the base scenario, each spot in the fringe area steadily loses carbon. In other words, while the base scenario assumes over-use of the fringe, the policy scenario scenario assumes sustainable use of the fringe. The sustainability might be achieved by more careful management or by simply harvesting less firewood and forage -- which would have costs! Our REDD policy simulation ignores most of these costs, so that the costs of a REDD scheme are somewhat underestimated.[4]

2.5. Is REDD a cheap way for richer countries to purchase emissions credits?

The argument is sometimes made that emission control by preventing forest clearing and degradation may be much cheaper for the world as a whole than other approaches, such as burying CO2 or using renewable energy. For example, after the Brazilian forest has been plundered for timber and charcoal, the cleared land may be used as beef pasture which raises little revenue. In such a case, a small REDD payment might be enough to preserve the forest. On the other hand, a large REDD payment might be insufficient to prevent

[4] Appendix C explores this aspect further, building on useful comments by Dr Hom Pant.

Indonesian rainforest from being converted to profitable oilpalm plantations. Clearly, within Nepal local conditions vary greatly, so that some places resemble Brazil, others Indonesia. There might be particular areas where a localized REDD scheme was attractive even with a low carbon price.

The data used in this study does not allow for such fine-grained geographical detail. Broad averages are used. Hence we overlook the possibility of some local "low-hanging fruit". On the other hand we assume a rather generous REDD payment ($US 50 per tonne of CO2).

3. The CGE model and its database

A fairly simple computable general equilibrium (CGE) model has been constructed specifically for this project. Like other CGE models[5] the model consists of equations describing:

- demands by industries and final demanders for commodities -- these are influenced by prices.
- demands by industries for capital, land and labour -- again influenced by prices.
- how commodity taxes affect user prices.
- market clearing: prices adjust to equate supply and demand for each commodity.
- how factor income is distributed, and the system of transfer payments between households, government and the rest-of-the-world (ROW).
- various macro indicators, such as GDP, GNP, CPI, etc.

Production technology is structured by a series of "nests", shown in Figure 3 below. In more detail:

- 62 industries are distinguished, each producing just one commodity. These are listed underneath Table 2. They include 13 agricultural industries: Paddy, Maize, Wheat, OthGrain, VegetFruit, Oilseed, SugarCane, PlantFiber, OthCrops, Cattle, OthAnmlPrd, RawMilk, Wool; and 4 forest industries: Firewood, Timbers, GrassFoddr, OForestPrd.
- Each industry and non-export final demander use 62 composite commodities -- each of which is a CES combination of a domestic good and its imported equivalent. Commodity prices and import/domestic shares are the same for all local users.
- For intermediate (industry) demand the 62 composite commodities are combined (via CES) into an aggregate "Intermediate goods" input, which is demanded in proportion to output.
- Industries also require, in proportion to output, a composite primary factor which is a CES aggregate of capital, land and labour used by that industry. Only agricultural and forest industries have a land input.
- Some local output goes directly to export; the rest is combined with imports to form the composite good.
- Each of the 7 household types demand the 62 composite commodities following the Linear expendituresystem (LES).
- The commodity mixes of investment and of government demands are exogenous.
- Exporters face foreign demand curves of constant elasticity -- typical values 4-8.
- Most of the CES, expenditure, and export demand elasticities are taken from the GTAP database. The figure shows some typical values.
- The supply of agricultural land is distributed between agricultural industries using a CET function with transformation elasticity 0.25. The total supply of agricultural land to all agricultural industries is exogenous, as is the total supply of land to all forest industries. Land inputs to forest industries move together (they are sharing the same land).
- Although not used in this project, the model allows for several types of labour, and for industries to produce a range of commodities.

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[5] The model is solved using GEMPACK. It is very similar to the PhilGem model described in Corong and Horridge (2012) and to the standard IFPRI GAMS CGE model (Lofgren et al, 2002), except that trade and transport margins are treated as direct demands. To compute and compare 40-year base and policy scenarios takes about 5 minutes. Archive Item TPMH0150 at http://www.copsmodels.com/archivep.htm contains materials sufficient to replicate the simulation reported here.

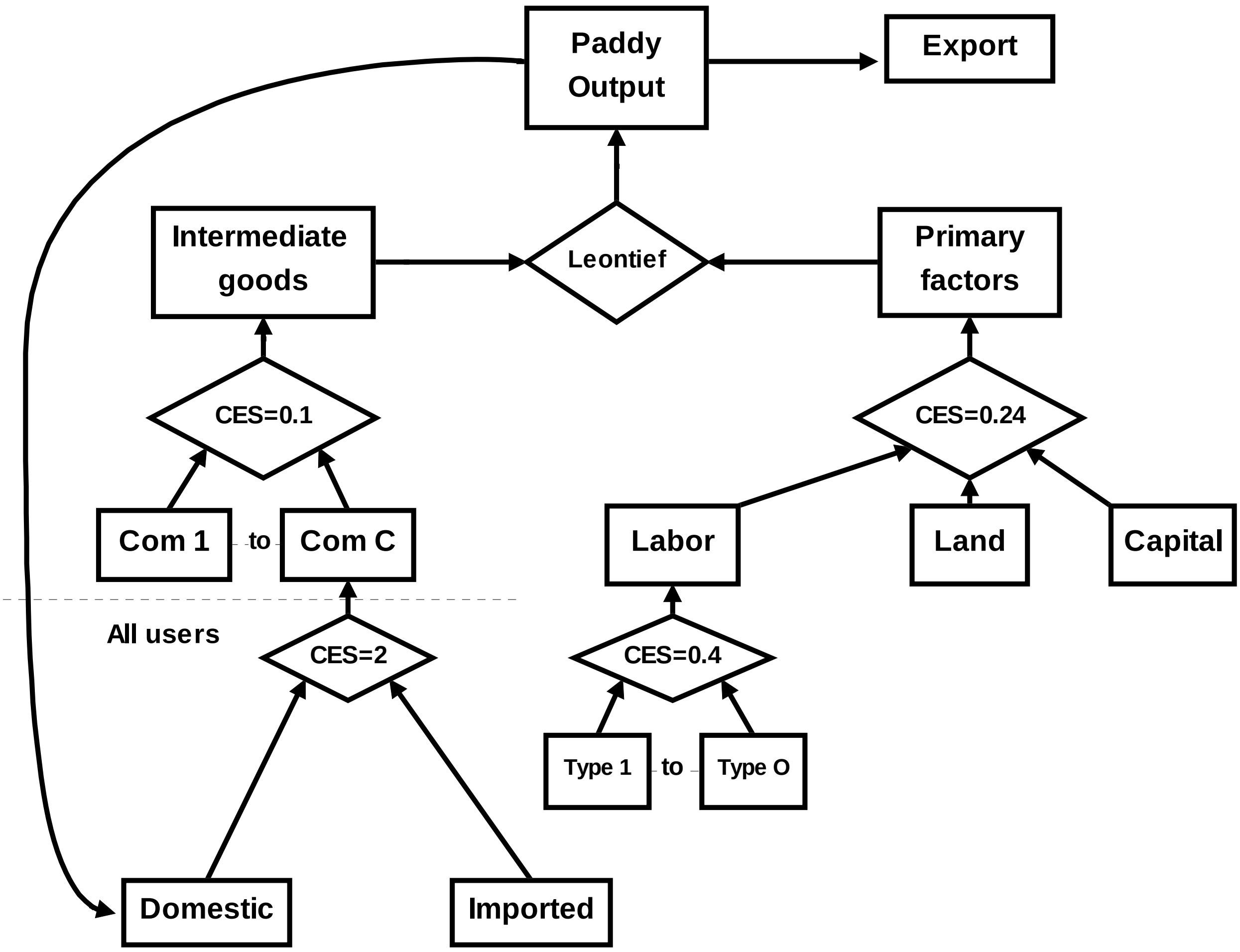

Figure 3. Production Technology

The model is multiperiod; of the recursive-dynamic type. The only dynamic mechanism is that which sets next-period sector-specific industry capital stocks to last-period stocks less depreciation plus last-period investment. Investment for each industry is positively related to that industry's rate of return on capital. Investors are myopic, but investment in each sector changes so that, after some time, capital earns an exogenous industry-specific rate of return. An open capital market is assumed, so that investment is not limited by Nepali saving.

The initial model database consists mainly of a Social Accounting Matrix (SAM) with 139 rows and columns. A SAM shows all monies received or spent by each sector and final demander [a cell in row i, column j shows funds flowing from j to i]. A summary appears in Table 2. There, yellow cells show flows of goods and primary factors (as seen in an input-output table), while other cells show transfer payments or subtotals. Apart from the SAM, the database contains:

- Various elasticities (like those shown in Figure 3).
- For each of Terai/Churia agriculture and forestry: land use in hectares, and share in value of national output.
- Investment in, and capital stock of, each of the 62 sectors.
- What proportion of consumption of each good by each household may be regarded as "subsistence" in the LES sense.

A feature of Nepal's economy is the importance of non-export income from overseas. The first part of Table 1 below shows the main components of GNP. The first five columns (locally generated factor income and taxes) add up to GDP. The last 2 columns represent income from overseas: 'remittances' are mainly the earnings of Nepali migrant workers, and 'aid' shows transfers to the government from the ROW; together they account for 13% of GNP, an unusually high share. The second part of the Table shows the main components of expenditure-side GDP. Imports are triple exports; the trade deficit is funded by the ROW income just mentioned. Also notable is the low share of government spending in GDP (just 7%).

Table 1. Components of GNP and GDP; from Nepal SAM, 2007, million rupees

GNP	Labour	Capital	Land	Commodity Taxes	Tariffs	Remittances	Aid	Total
Values	285158	375500	71658	70425	12627	91978	25854	933201
% Shares	31	40	8	8	1	10	3	100
GDP	Households	Investment	Government	Exports	- Imports	Total		10
Values	741903	172120	57642	70703	-227000	815368		
% Shares	91	21	7	9	-28	100		

3.1. The closure

Most CGE model contain more variables than equations. Hence some variables have to be exogenous -- set by the model user. There is some flexibility in the choice of exogenous variables: the chosen set is called the *closure*. Here the same closure is used in both base and policy simulations. The following variables are exogenous:

- Tax rates, and rates of technological changes
- Import prices, and the positions of export demand curves
- ROW transfers to Nepal households and government (including REDD payments)
- Employment; and land available for forestry and agriculture
- Target rates of return to capital: investment in each industry goes up or down according to whether the current rate of return is above or below the target rate.
- The exchange rate (acting as numeraire).
- External balance (= exports + ROW transfers to Nepal Households and government - imports).

Household spending follows household income, and government spending on goods follows GNP. But in each case the propensity to consume is adjusted by a single scale factor that allows the external balance conditions to be met. The effect of this is that REDD payments allow both government and household spending to increase (implicitly the REDD payment is shared between households and government). Obviously the question of how the REDD payments are distributed is important; we simulate a neutral scheme.

Table 2. Social Accounting Matrix (SAM), Nepal, 2007, aggregated, million rupees

	Industries	Commodities	Labour	Capital	Land	Households	ComTax	Tariff	Government	ROW	Investment	Total
62 Industries	0	1126303	0	0	0	0	0	0	0	0	0	1126303
62 Commodities	393986	0	0	0	0	741903	0	0	57642	70703	172120	1436354
Labour	285158	0	0	0	0	0	0	0	0	0	0	285158
Capital	375500	0	0	0	0	0	0	0	0	0	0	375500
Land	71658	0	0	0	0	0	0	0	0	0	0	71658
7 Households	0	0	285158	375500	71658	0	0	0	9985	91978	0	834280
ComTax	0	70425	0	0	0	0	0	0	0	0	0	70425
Tariff	0	12627	0	0	0	0	0	0	0	0	0	12627
Government	0	0	0	0	0	16000	70425	12627	0	25854	0	124906
ROW	0	227000	0	0	0	0	0	0	0	0	0	227000
Investment	0	0	0	0	0	76377	0	0	57279	38464	0	172120
Total	1126303	1436354	285158	375500	71658	834280	70425	12627	124906	227000	172120	4736331

Note: A 2007 SAM of Nepal was prepared by Dr D.R. Khanal, as described in Appendix B. His SAM has 139 rows and columns; in the summary above rows and column for the 62 sectors and 7 household types have each been combined. The original 62 sectors are: Paddy, Maize, Wheat, OthGrain, VegetFruit, Oilseed, SugarCane, PlantFiber, OthCrops, Cattle, OthAnmlPrd, RawMilk, Wool, Firewood, Timbers, GrassFoddr, OForestPrd, Fishing, Coal, Oil, GasMining, OthMining, Meat, MeatPrd, VegetblOil, DairyPrd, GrainMill, Sugar, OthFoodPrd, DrinkTobac, Textile, Clothing, LeatherPrd, Lumber, Paper, Petroleum, ChemRubber, MineralPrd, IronSteel, NonFerrMtl, FabricMetl, MotorVehcl, OthTrnsEqp, ElctrncEqp, OthMechEqp, Furniture, OthManuf, Electricty, Gas, Water, Construct, Trade, OthTrnsprt, WtrTrnsprt, AirTrnsprt, Communictn, Finance, Insurance, OthBusSvc, RecOthSvc, GovSvc and Dwelling. The 7 household types have different patterns of income and expenditure: the table below shows source shares in disposable income.

Table 3. Income sources by household type, percentages of after-tax income

	Labour	Capital	Land	Government	ROW	LessTax	Total
RurLndNone	64.0	22.5	0.0	1.4	12.1	0.0	100
RurLndSmall	62.5	16.8	1.6	1.6	17.5	0.0	100
RurLndMedium	26.0	50.8	10.4	0.4	12.5	-0.1	100
RurLnLarge	3.7	62.9	28.3	0.7	8.2	-3.8	100
UrbLowEduc	64.8	17.8	3.8	4.2	10.6	-1.1	100
UrbMedEduc	24.7	68.4	5.4	3.3	4.0	-5.8	100
UrbHighEduc	4.2	97.0	4.3	1.1	5.3	-11.8	100

4. The base forecast

The base forecast is designed to serve as a plausible scenario for the future path of the Nepalese economy in the absence of a REDD scheme. Its main function is to serve as a point of comparison for an alternate, policy, scenario which does include a REDD scheme. The difference between the two scenarios is interpreted as the effect of the REDD scheme.

- Obviously the future paths of foreign prices, technological change, foreign demand for Nepalese labour, etc, are unknown and have to be guessed. The same guesses are used for base and policy forecasts.
- Plausible variations in the set of assumptions which are common to base and policy forecasts usually have only a small effect on the difference in results between base and policy scenarios.

Hence, details of the base forecast are not strongly relevant to analysis of effects of the REDD policy. Nonetheless the base forecast is of considerable interest in its own right, so the main features are described below.

The following exogenous changes were imposed for each year of the base forecast. :

- 2% annual productivity increases for all labour and land inputs used by industries
- 1.4% annual population increase (reflecting recent history) and a 2% annual increase in the labour force (the difference between these two reflecting the 'demographic dividend' associated with a reduced birth rate).
- An increase in demand for Nepalese exports of 3.5% p.a.

The above assumptions reflect an expectation that the future annual rate of real GDP growth will be about 3.7% -- similar to the average of the last decade[6]. They imply that per-capita GDP will rise by about 2% p.a. -- more than doubling in 40 years. That suggests that Nepal may become less dependent on non-export income from abroad. The next three assumptions reflect this idea:

- An increase in foreign currency remittances to Nepalese households from the ROW of 3% p.a. -- these mainly comprise the earnings of Nepalis working abroad. Thus foreign labour earnings as a fraction of GDP are assumed to fall slowly.
- NO increase in (non-REDD) donations by the ROW to the Nepalese governement (Aid frozen at 2007 levels).
- A gradual movement towards external balance, ensuring that the value of exports, plus remittances from the ROW to households and government, are sufficient to pay the import bill. That is, the 2007 excess of imports over foreign income is gradually reduced (by 10% per year).

Lastly we assume, in the base forecast only:

- Annual conversion of 2617 hectares of Terai/Churia land from forest to agriculture. That translates to an increase of 0.1% p.a. in the national supply of agricultural land, with a corresponding decrease of 0.1% p.a. in the forest area.

Tables 4 and 5 show some results from the base forecast. Table 4 shows changes in selected macro aggregates, both as total changes over the simulated period; and as annual percent changes. As intended, real GDP grows at an average rate of 3.7%, but real GNP and and real household and government consumption grow at a slightly lesser speed. This reflects our assumption of a gradual movement towards external balance. Similarly, exports grow more than imports.

The Aggregate Land variable xlnd_i grows at a small rate -- even though the total hectares allocated to Agriculture or forestry remains unchanged. This is because xlnd_i is an average of land used by different sectors, weighted by the rental value of land in each sector. The small increase arises because forest (which has a low per-hectare rental) is being turned into agricultural land (which earns more). This causes xlnd_i to increase, and contributes slightly to increased GDP.

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[6] See for example: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG/countries/NP?display=graph

Table 4. Base forecast, total and average annual percent changes 2007-2047, selected macro variables

Description	Model variable	total % change	average annual % change
Real household consumption	xhoutot	265.7	3.29
Real investment	xinv_c	353.5	3.85
Real government consumption	xgov_c	282.0	3.41
Real GNE (absorption)	xgne	281.7	3.41
Real exports	xexptot	664.0	5.21
Real imports	ximptot	251.8	3.19
Real GDP	xgdpexp	323.3	3.67
Aggregate capital	xcap_i	336.5	3.75
Aggregate labour	xlab_oi	120.8	2.00
Aggregate Land	xlnd_i	3.6	0.09
Total factor inputs	xgdpfac	185.5	2.66
Real GNP	xgnp	308.6	3.58
Real GDP per capita	xgdppc	134.3	2.24
Real GNP per capita	xgnppc	134.3	2.15

Table 5 shows some broad sectoral results: to save space we have aggregated these results from the model's 62 sectors down to 13 broad sectors. Three mechanisms drive these sectoral results:

- Unit land rents rise steeply, reflecting the fixity of land supplies. The higher rents cause price rises for local Crops, Livestock, Forest and (indirectly) Food. Imports grow most (and exports and output least) for these sectors.
- In the "Local Use" column, rising household incomes and higher expenditure elasticities for manufacturing and service outputs cause local demand for those goods to rise more.
- Exports increase sharply, except in the land-contrained sectors.

Table 5. Base forecast, average annual percent changes 2007-2047, selected broad sector variables

	Output	Exports	Imports	Local Use	Price (dom)	Land rent
Model variable→ Broad Sector ↓	aggxtot	aggxexp	aggximp	aggxcmp	aggpdom	aggplnd
Crops	2.46	2.13	3.06	2.54	0.30	3.94
Livestock	2.69	1.13	4.52	2.86	0.58	4.61
Forest	2.87	-1.03	4.28	2.90	0.49	7.51
Fishing	3.42	4.02	3.12	3.37	-0.20	
Mining	4.44	5.65	3.48	3.83	-0.41	
Food	2.93	3.27	2.98	2.90	0.05	
Manufact	4.44	5.85	3.37	3.70	-0.29	
Utilities	4.04	0.00	2.78	3.87	-0.44	
Construction	3.99	0.00	2.94	3.85	-0.53	
TradeTrans	4.17	5.39	3.07	3.96	-0.47	
Services	4.21	5.55	3.13	4.04	-0.49	
GovSvc	4.21	5.96	2.71	3.69	-0.62	
Dwellings	4.08	0.00	0.00	4.08	-0.50	

5. The policy forecast

The policy forecast is the same as the base forecast but with two differences:

- From 2015 **there is no further** annual conversion of 2617 hectares of Terai/Churia land from forest to agriculture.
- From 2015 **there is an annual REDD payment** of 2716 million NPR paid from ROW to Nepal. The amount is calculated in Appendix A, and corresponds to a $US 50 CO2 price[7]. The REDD payment allows both household and government spending to expand by an equal percentage[8].

Following normal practice, we report policy results as differences from the base scenario. For example, a 2047 0.5% GDP decrease should be interpreted to mean that in 2047 GDP in the policy scenario is 0.5% less than in 2047 in the base scenario. In other words, we report cumulative percentage deviations from base. A chart showing such deviations in 7 important real macro variables is shown below.

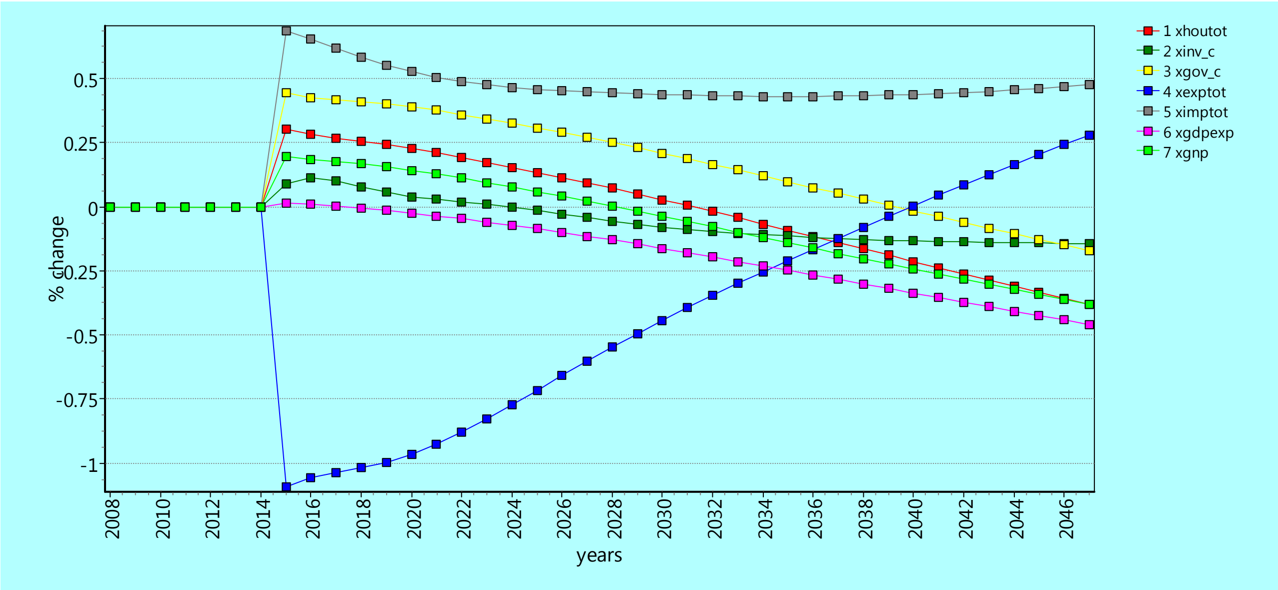

Figure 4. Macro variables, cumulative percentage deviations from base

According to the chart, when the REDD scheme is introduced in 2015, real household consumption (xhoutot, in red) jumps by about 0.3%. But that increase declines over time, so that around 2032 consumption is at the base level, and after that it is less than in the base scenario. Real GNP (xgnp, in limegreen) follows a similar path. By contrast, real GDP (xgdpexp, in purple) jumps very slightly initially, then steadily declines to nearly 0.5% below base by 2047. By any of the 3 measures, the REDD scheme leaves Nepal worse off in 2047.

To understand these results, we should bear in mind that:

- Macro effects are small, since the size of the scheme simulated here is small relative to GDP.
- Compared to the base scenario, the REDD scheme consists of two components:

A. a 2015 increase in payments from ROW to Nepal of 2716 million NPR, continuing at that level thereafter.

B. an annual transfer of 2617 hectares of Terai/Churia land from high-rent agriculture to low-rent forests. This causes a continuing, cumulative, reduction in agricultural output and GDP.

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[7] We assume that other foreign aid payments are not reduced -- although it is of course possible that aid could be 'relabelled' as REDD funds, without increasing the total amount. Both the $50 CO2 price and the 2617 hectares p.a. change in land use change are simply illustrative assumptions. A much smaller CO2 price, say $5, would yield very gloomy results. Estimates of the CO2 price needed to hugely reduce rich-world emissions are normally in the $30-$100 range. The CO2 price could also change over time.

[8] Conceivably, a wisely-directed increase in government spending might increase future productivity -- but we did not include such a mechanism.

Thus this REDD scheme front-loads the REDD's benefits and defers the costs. Each year, Nepal receives 2716 million NPR, and in return loses a further 2617 hectares of agricultural land forever. Eventually the costs exceed the benefits[9].

To understand the interaction of mechanisms A and B above, it is helpful to simulate their effects separately. The total effect is approximately the sum of the two individual effects. The chart below shows the effect of only A -- the 2716 million NPR annual ROW payment (with no change in forest clearing).

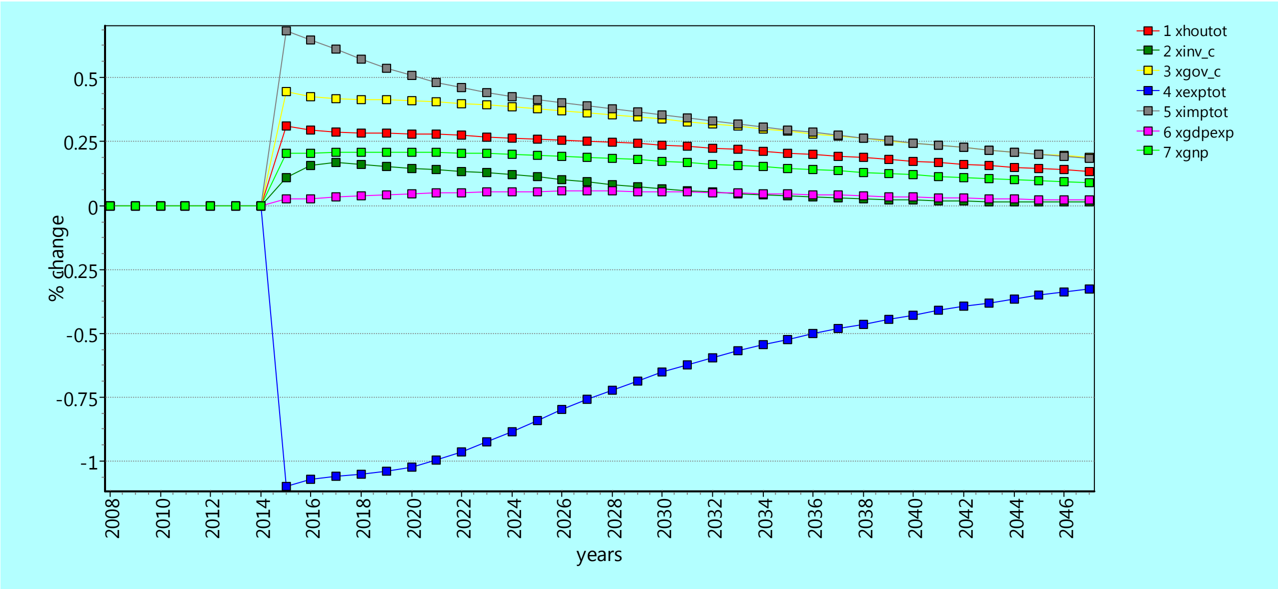

Figure 5. Macro variables, REDD payment only

The gift of foreign exchange has little effect on Nepal's output or real GDP (xgdpexp, in purple). With fixed endowments of labour and land and a fixed rate of return to capital[10], we should not expect real GDP to change much. Rather the gift allows Nepalis to consume more without producing more; so the trade balance worsens. Imports (ximptot, grey) rise and exports (xexptot, blue) decrease. With the payment fixed, the percentage effects get smaller over time, since GDP is growing over the period.

The next chart shows the effect of only B -- the annual loss of agricultural land.

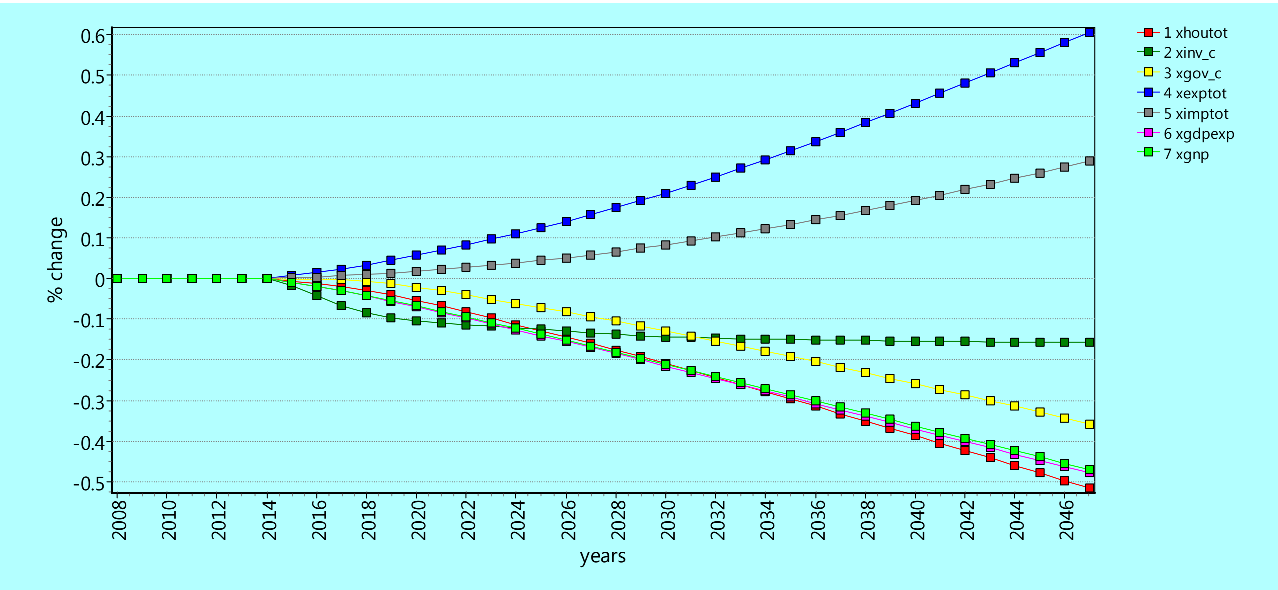

Figure 6. Macro variables, stop deforestation only

[9] Implicitly we assume a zero discount rate here. With a high enough discount rate, 2716 million NPR today could compensate for the perpetual loss of 2617 hectares of agricultural land.

[10] In the model, rates of return to capital vary in the short run, but tend to return to normal levels over time.

Above, GDP, GNP, and household consumption fall steadily, until in 2047 they are about 0.5% less than in the base scenario. Imports (especially of food) rise, so to preserve trade balance exports must also rise. Initially, exports are much smaller than imports (Table 1), so the trade-balancing percent export rise is larger than the percent import increase.

The combined effect, shown in Figure 4, is that initial benefits of the REDD scheme are eroded and reversing by steadily increasing costs.

5.1. Broad sectoral effects

The table below shows end-period effects of the REDD scheme for broad industry sectors. Less land for agriculture means higher land rents, reduced output, and higher crop (and food) prices. The opposite applies to the Forest sector, which has more land available -- but because the forest sector is much smaller than agriculture, this good news does not outweigh the bad. Increased food imports are balanced by export increases for Manufacturing and Services.

It should be emphazied that these effects are fairly small. The REDD may cause 2047 Crops output to fall by 2.37% relative to the base scenario, but in the base scenario Crops output grows by more than that each year (see Table 5).

Table 6. Broad sectoral effects, , percent deviation from 2047 Base scenario

	Output	Exports	Imports	Local Use	Price (dom)	Land rent
Model variable→ Broad Sector ↓	aggxtot	aggxexp	aggximp	aggxcmp	aggpdom	aggplnd
Crops	-2.37	-9.67	3.17	-1.56	2.61	6.05
Livestock	-2.68	-8.82	3.96	-1.93	2.68	5.51
Forest	1.90	15.31	-5.01	1.81	-2.72	-7.72
Fishing	-0.22	-0.35	-0.03	-0.21	0.14	
Mining	0.13	0.63	-0.21	-0.11	-0.15	
Food	-2.33	-5.13	0.83	-0.71	1.18	
Manufact	0.43	1.54	-0.07	-0.05	-0.18	
Utilities	0.05	0.00	-0.46	-0.01	-0.18	
Construction	-0.08	0.00	-0.58	-0.14	-0.26	
TradeTrans	0.32	0.79	-0.16	0.22	-0.21	
Services	0.19	0.97	-0.30	0.09	-0.21	
GovSvc	0.14	0.71	-0.35	-0.06	-0.19	
Dwellings	0.12	0.00	0.00	0.12	-0.24	

5.2. Effects on different households

The table below compares end-period nominal and real effects of the REDD scheme between different household groups. The several household types distinguished by the SAM have different income (see Table 9) and expenditure patterns, leading to differential incidence of income and price effects. The first column shows effects on post-tax nominal factor income -- which on average are small (last row). However, labour's share of GDP is falling, whilst the land share is rising. So the poor, who depend most on labour income, do worse, while larger landowners do best.

The second column shows effects on living costs -- which on average rise by 0.6%. But high land rents cause high food prices; and the poorer groups spend more on food, so for the poor, CPI rises more. The net effect, which is doubly regressive, is shown in the third (real income) column.

Neither nominal or real factor incomes shown below take into account the redistribution of REDD payments from the ROW. As explained earlier, the REDD distribution is neutral in effect: the closure ensures that REDD funds allow for each household and the government to increase goods purchases by the same percentage amount. Hence real consumption by household (the last column) is uniformly 0.21% greater than the previous column. Still, the only winners are the large landowners.

Table 7. Nominal and real effects by household type, percent deviation from 2047 Base scenario

	Nominal Income	CPI	Real Income	Real Consumption
RurLndNone	-0.35	0.83	-1.17	-0.96
RurLndSmall	-0.27	0.70	-0.96	-0.75
RurLndMedium	0.08	0.61	-0.52	-0.31
RurLnLarge	0.60	0.51	0.09	0.30
UrbLowEduc	-0.19	0.33	-0.52	-0.31
UrbMedEduc	-0.07	0.24	-0.32	-0.11
UrbHighEduc	-0.09	0.21	-0.30	-0.10
All households	0.01	0.58	-0.56	-0.38

The regressive direct effects of the REDD scheme, shown above, point to the need for a targeted distribution of REDD funds, favouring those harmed most: the poor and landless.

6. Conclusion

We have examined the effects of one possible REDD scheme, finding that initial benefits to Nepal's economy are in time reversed by the loss of agricultural land. Different REDD schemes could have been simulated, including those with a higher carbon price. Those might have proved more advantageous to Nepal. We could also have assumed a higher (or lower) future growth rate for the Nepalese economy -- but this probably would not much affect our judgement of any particular REDD scheme.

Our simulation results draw on sketchy data and brave assumptions. Like any forecast about the future, they should be treated with caution. Nevertheless some broad conclusions are clear:

- A fairly high carbon price is needed to entice Nepal into a REDD scheme.
- The 'front-loading' feature of REDD -- payments are received now to compensate for future non-use of agricultural land -- could be tempting for the Nepalese government, but offers the potential to steal from future generations of Nepalis. As well, ROW funders of the scheme may worry that REDD payments may reward a cessation of forest clearing, but will not be repaid if clearing later resumed.
- A REDD scheme is not naturally pro-poor. Special measures would be needed to undo regressive income and price effects.

These conclusions suggest that hard bargaining, and careful redesign of the basic REDD scheme may be needed if REDD is to benefit Nepal.

More attractive schemes, which might reward Nepal for forest stewardship rather than for emissions saved, have been proposed (often called REDD+). For example, REDD+ revenue might cover the cost of planting and nurturing new trees in mountain areas unsuitable for farming. Possibly, the recent earthquake may accelerate the depopulation of the Hills areas, opening up new possibilities for replanting degraded forests or abandoned agricultural land. Here too REDD+ revenue might cover the costs of restoration. This study has evaluated a basic REDD scheme according to a rather narrow, national, economic focus. By contrast, REDD+ schemes are usually judged according to wider social and environmental criteria, taking into account local opportunities for community involvement and for the preservation of biodiversity. To explore such options would require a separate in-depth study.

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Appendix A: Calculations underlying the simulations

In this section we detail some data sources and calculations used to estimate:

(a) the annual economic benefit to Nepal of Terai/Churia deforestation in the absence of a REDD scheme.

(b) the annual REDD payments if Terai/Churia deforestation were to cease.

These values, which drive model results, are estimated outside the model, via simple (but tedious) calculations. We start with some forest areas drawn from FRA surveys:

Table A1. Historical area change calculations

	Start year	Initial area	End year	Final area	N year	Change	Annual change	2007 estimate
TERAI	1991	440100	2010	408100	19	-32000	-1684	403047
CHURIA	1995	1411790	2010	1373740	15	-38050	-2537	1366130
				1781840			-4221	1769177

The estimates of 2007 areas are interpolated.

We assumed that 62% of the disappearing forest became cropland (source: FRA/DFRS 2014).

62% of 4221 is 2617 = annual cropland taken from forest.

We use this figure to estimate Terai/Churia agricultural area in 2007:

Agriculture area 2010 FRA TERIA + CHURIA = 1397000+472000 = 1869000.

Assuming it grew by 2617 ha/pa during 2007-2010, Terai/Churia agriculture in 2007 was 1861149 ha

Emissions

According to the latest FRA reports, the Terai forests contained 89 tonne/ha of above-ground carbon, while the Churia forests contained 85 t/ha. We assumed the average was 87 t/ha of above-ground Carbon. We multiply 87 by 3.67 to convert to CO_2, getting 319.29 t/ha of CO_2 (which, we assume, = CO2e).

So we assume turning a hectare of Terai/Churia forest into cropland releases 319.29 tonnes of CO_2.

Thus annual conversion of 2617 ha of forest to agriculture would annually emit 835582 tonnes of CO_2 (=2617*319.29).

The value units for the initial model database are 2007 million Nepalese Rupees (NPR). In 2007 one $US exchanged for 65 NPR. So a $US 50 CO2 price = 0.00325 (=50*65/1000000) million NPR per tonne.

Hence the REDD reward for NOT turning a hectare of Terai/Churia forest into cropland is a one-off payment 319.29*0.00325 = 1.0376925 million NPR. To eliminate annual forest loss of 2617 ha would earn 2716 million NPR pa.

Figures from the model database imply that land's economic contribution per hectare is far less for Forestry than for Agriculture.

Table A2. Area and rent calculations

	1	2	3	4	5	6	7	8
Value-added	Labour	Capital	Land	Total	Terai/Churia share[11]	Terai/Churia land rent	Terai/Churia area	Terai/Churia rent per ha
1 Agr	93598	53138	70086	216822	0.7	49060.2	1860136	0.026374521
2 For	7066	10179	1572	18818	0.6	943.2	1794503	0.000525605
3 Other	184494	312182		496676				
Total	285158	375500	71658	732316				

Hence the economic reward for turning a hectare of Terai/Churia forest into cropland is a perpetual annual payment of 0.025848916 million NPR (=0.026374521-0.000525605), if rents remained at 2007 levels. In fact, land rents increase sharply in our base scenario, so the reward increases over time.

Sources:

FRA/DFRS. 2014. Terai Forests of Nepal (2010 – 2012). Babarmahal, Kathmandu: Forest Resource Assessment Nepal Project/Department of Forest Research and Survey. Available at http://www.franepal.org/wp-content/uploads/downloads/publications/TeraiForestsofNepal_23April2014_LowResolution.pdf

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[11] Estimates provided via D.R.Khanal. In this table "Terai" includes also Churia.

Table A3. Extract from base-period SAM: primary factor payments by sector

Note: the original SAM, supplied by D.R.Khanal, included no land contribution to Forestry. That SAM was adjusted so that land shares in value-added for Agriculture and Forestry sectors approximated those in the GTAP database, while row and column totals in table below remained unchanged.

Sector	Labour	Capital	Land	Total
1 a_Paddy	15894	12571	12916	41381
2 a_Maize	6113	3092	4420	13625
3 a_Wheat	8508	2203	5491	16203
4 a_OthGrain	6800	3440	4916	15156
5 a_VegetFruit	23017	22818	20154	65988
6 a_Oilseed	2084	1761	1729	5574
7 a_SugarCane	1657	1070	1271	3997
8 a_PlantFiber	219	97.2	120	437
9 a_OthCrops	3318	1822	2451	7591
10 a_Cattle	2954	1619	1939	6511
11 a_OthAnmlPrd	6488	458	5279	12226
12 a_RawMilk	16406	2180	9326	27912
13 a_Wool	142	6.22	74	222
14 a_Firewood	4119	5926	916	10961
15 a_Timbers	1046	1292	213	2551
16 a_GrassFoddr	1866	2911	435	5213
17 a_OForestPrd	35.1	50.6	7.82	93.6
18 a_Fishing	264	1690	0	1955
19 a_Coal	15	36.1	0	51.1
20 a_Oil	26.1	138	0	164
21 a_GasMining	48.5	186	0	234
22 a_OthMining	609	2735	0	3344
23 a_Meat	168	240	0	408
24 a_MeatPrd	185	282	0	467
25 a_VegetblOil	395	817	0	1212
26 a_DairyPrd	348	1491	0	1839
27 a_GrainMill	1338	5732	0	7069
28 a_Sugar	227	545	0	772
29 a_OthFoodPrd	489	869	0	1358
30 a_DrinkTobac	1147	3565	0	4712
31 a_Textile	830	691	0	1521
32 a_Clothing	548	1652	0	2200
33 a_LeatherPrd	215	819	0	1034
34 a_Lumber	25.8	175	0	201
35 a_Paper	346	1101	0	1447
36 a_Petroleum	11.2	73.2	0	84.4
37 a_ChemRubber	773	7022	0	7796
38 a_MineralPrd	538	2227	0	2765
39 a_IronSteel	205	1482	0	1687
40 a_NonFerrMtl	289	5639	0	5928
41 a_FabricMetl	726	12585	0	13311
42 a_MotorVehcl	83.8	5.68	0	89.5
43 a_OthTrnsEqp	36	13.8	0	49.8
44 a_ElctrncEqp	124	38.1	0	162
45 a_OthMechEqp	491	4380	0	4871
46 a_Furniture	58.6	398	0	457
47 a_OthManuf	268	310	0	578
48 a_Electricty	2006	11011	0	13016
49 a_Gas	214	610	0	824
50 a_Water	76.9	460	0	537
51 a_Construct	22866	10228	0	33093
52 a_Trade	25476	76565	0	102041
53 a_OthTrnsprt	17589	59874	0	77463
54 a_WtrTrnsprt	0	33	0	33
55 a_AirTrnsprt	2706	7507	0	10213
56 a_Communictn	2227	3095	0	5322
57 a_Finance	2420	1111	0	3531
58 a_Insurance	6035	9542	0	15577
59 a_OthBusSvc	8884	12365	0	21249
60 a_RecOthSvc	11162	11368	0	22531
61 a_GovSvc	53319	7600	0	60919
62 a_Dwelling	18686	43875	0	62560
Total	285158	375500	71658	732316

Appendix B: Data Sources and Methods Used in Updated and Extended 2007 SAM

Dr Dilli Raj Khanal

Social accounting matrices (SAMs) are the most comprehensive and consistent data systems with disaggregated information on production, aggregate demand components and factor distribution by different industries, institutions and agents including similar information on external balances and imbalances through coverage on exports and imports of goods and services, transfers and capital flows, among others. Based on the level of disaggregation, SAMs enable to get comprehensive idea on the structure of an economy or economies including production and distribution relations in a consistent manner by bringing together both macro and micro level data (Pyatt and Thorbecke, 1976). For these reasons, the accounting matrix of a SAM requires portraying economic relations by distinguishing (1) total domestic supply of commodities (2) activity accounts for producing sectors (3) main factors of production such as land, labor and capital (4) current account transaction between main institutional agents such as households, corporate enterprises, government and the rest of the world (5) the rest of the world and (6) at least a consolidated capital account (domestic and rest of the world) to capture the flows of savings and investment by institutions and the rest of the world. They, in turn, are the building blocks of computable general equilibrium models (CGEs), immensely useful in policy simulation exercise (Dervis, Melo and Robinson, 1982).

Thus, construction of a disaggregated input/output table and SAM requires detailed information on domestic supplies by industries/firms added by similar information on imports to represent total supplies of an economy. As a counterpart, it also needs similar detailed information on the uses side in terms of intermediate consumption, final consumption, gross capital formation and exports. The factor distribution in terms of, among others, labor and capital share must be an integral part of a SAM. Besides detailed information on taxes, transfers and subsidies, special treatment of trade, transport and financial services margins is also required for avoidance of double counting and take price factor into account. This is the reason why a huge macro and micro level reliable data with information on inputs and outputs including information on external trade and payments and factor distribution is required for such exercises.

Paucity or lack of such reliable data and information has constrained construction and institutionalization of more robust disaggregated input output tables in Nepal to be useful for policy modeling or simulation exercises despite such an initiative from the late 1980s and continued efforts thereafter. Today, a disaggregated 57 *57 input/ output table with base year 2000/2001 is available but it has very aggregative SAM (IPRAD, 2007). Although a more disaggregated 57*57 sector SAM 2007 is available, it has only one forestry sector (Raihan and Khondker, 2011) and hence, despite being important benchmark, it does not allow more detailed exercise for this sector from the point of view of exploring alternative mitigating policy measures. Moreover, a closer review of data sources and derived levels at both macro and sectoral level show some inconsistencies in the SAM 2007. This was due to numerous data sources with different formats and many bold assumptions for generating the required data or fulfilling the data gaps.

An important recent development is that based on huge data sources and information, Central Bureau of Statistics has compiled a comprehensive 51 sector supply and 51 sector use table for the year 2004/05 (CBS, 2013). A quick review shows that in the table over all consistency in terms of supply and corresponding uses has been maintained. Such a supply and use table has been taken as a benchmark to construct a new SAM for the year 2007[12].

A quick review of the tables shows that numerous data sources were used for the estimation of tables. Around 35 bench mark surveys carried out in 2004/05 by the CBS were the primary data sources. Likewise, administrative records of enterprise financial statements were extensively used for estimating the inter-

[12] Details on the data sources and methodology used in the preparation of Supply and Use Tables of Nepal 2004/05 are found in CBS Occasional Paper (CBS, 2013).

industry domestic supply of major inputs. Censuses of manufacturing establishment 2001/02 and 2006/07 were the major sources for the manufacturing sector. These Censuses provide detailed information on input purchase and supplies at a disaggregated level as per ISIC classification helping to trace out the total supply and corresponding uses. Nepal's first distributive trade survey 2007/08 was used to estimate both transport cost and trade margins. The survey gives the detail layout of the trade margin in dealer, wholesale and retail level trade for domestically produced and imported goods. The intermediate costs associated with freight charges are also reported there facilitating to derive the transport cost share.

For the import matrix of goods, Department of Customs was the basic data source. It maintains the international trade statistics in HS classification scheme. HS classification was used to transform to CPC by using correspondence mechanism. Matrix of imports of services was based on BOP statistics. Such data are available from the Central Bank of Nepal which publishes in a monthly basis. Information on the insurance and freight services incurred by non-resident from BOP statement was used to adjust CIF/FOB. Freight and insurance services were proportionally apportioned to imports. Export matrix was prepared for both exports of good and exports of services using the similar source and methods. Separate vectors for government expenditure were computed based on the government finance statistics.

The matrix in the table consisted of value added tax on domestic production, excise duty on some selected commodities and value added tax on imports. Information on taxes was based on the information provided by the Department of Inland Revenue and Department of Customs. In such calculations, domestic production including VAT exemptions was also taken into consideration. Information on subsidies was based on the government finance statistics.

The gross fixed capital formation was estimated by using commodity flow method. For this, two basic mechanisms of supply i.e. domestic supply (adjusted for exports) and imports were analyzed. Output of the construction was also adjusted accordingly. The new independent method was used to estimate the change in stock based on the information provided by government owned trading and other corporations, balance sheets and benchmark surveys.

Compensation of employees was estimated by using government financial statistics to administrative records and enterprise financial statements. Beside these secondary sources, the bench mark surveys and censuses of manufacturing establishment of 2001/02 and 2006/07 were used. For some subsectors of manufacturing, trade and business, the compensation was apportioned by the output. For taxes less subsidies, government financial statistics was the major data source. Depreciation was not calculated separately in the absence of required minimum data. The operating surplus representing the profit or retained earnings was derived residually by deducting the compensation and taxes less subsidies from value added.

In addition to deriving the coefficients from both supply and use tables prepared based on the above mentioned sources , a number of additional works were carried out to extend the sectors to be useful for more detailed forestry related exercise and introduce various additional elements that were essential to construct a standard SAM.

In the beginning, detailed data sheet prepared and used for the 51 sector supply and 51 sector use table were used to disaggregate sectors like forestry, agriculture and manufacturing. In the new table, forestry sector has been disaggregated into four, viz, firewood, timbers, grass/fodders and other forestry products. Similarly, a new furniture sector has been created to find out particularly the extent of its linkages with the forestry sector. Given the importance, maize has been separated from other grains. Altogether, the supply and use table was extended to 62 sectors.

Another important feature is that at least eight household’s type viz, rural landless, rural land small, rural land medium, rural land large as well as urban lower education, urban medium education and urban higher education are distinguished in the new SAM. Both income sources and expenses are shown accordingly in the SAM. For such calculations, information contained in the NLSS 003/04 has been used. By examining the income and expenditure structure, the share distribution has been made among 7 representative household groups and 62 SAM commodities. Foreign aid has been introduced more specifically as this is the major source of government funding which is also a possible major source of REDD+ in future.

After deriving the coefficients within comprehensive and consistent SAM framework, the table was transferred into 2006/07 bases by multiplying the coefficients with the control totals available from the national accounts, government budgetary sources and central bank BOP data, among others, for the fiscal year 2006/07. The intermediate input totals and factor distribution numbers were derived from the working sheets of national accounts.

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Appendix C: Revenue from Forest Destruction

The analysis presented in the main text assumes that replacing a hectare of forest with cropland has the following costs and benefits:

(a) adding a stream of agricultural rent which continues into the future;

(b) foregoing a stream of forest rent which continues into the future. We assume that this income derives from sustainable use of the forest (the forest does not degrade).

(c) paying (if a REDD scheme is in operation) a fine based on emissions caused by forest clearing. This is a one-off payment.

Since per hectare rentals are less for forest than for crops, the REDD penalty is needed to discourage forest clearing.

Dr Hom Pant has pointed out that this calculation ignores an important economic benefit of forest clearing: the revenue from selling logs harvested during clearing. More generally (as pointed out in the main text) some log, forage and firewood output that exceeds sustainable levels would be unavailable if forest clearing were halted. To analyse this with precision, we would need to know what proportion of say, logs, came from clearing land (as opposed to logs from selective, sustainable harvesting). Although we do not have data to support this, we can make some approximate calculations.

The Terai native forest is fairly mature; and current (official) harvesting permits only the removal of mature (say 80-year old) trees. If the usable timber in a tree increased linearly over time, the timber gained by chopping down a whole area of forest might (in that year only!) be 40 times the timber gained annually by sustainable harvesting. A 2.5% discount rate would be low enough to make the continued revenue from sustainable use seem as attractive as the immediate reward from destruction (here we are ignoring both the environmental benefits of forest preservation, and the possible revenues yielded by alternative crop use).

Table A2 of Appendix A suggests that Terai/Churia forest rentals are 0.000525605 million NPR per ha. Multiplying this by 40 we may estimate that 0.0210242 million NPR per ha might be yielded by clearing a hectare and selling the logs. But we calculated that the REDD reward for NOT doing this was 1.0376925 million NPR -- 50 times larger. Hence the REDD payment need not be significantly increased to offset the potential log revenue from clearing forest.

On the other hand, Dr Pant's observation points to a second source of error. The figures presented inTable A1 of Appendix A suggest that Terai forest has been disappearing at the rate of 0.4% p.a. That suggests that 13.8%[13] of log output may have arisen from forest clearing rather than from sustainable harvesting. That is, for the Terai, we may have over-estimated the income from sustainable harvesting by 13.8%. If appropriate adjustments[14] were made to our CGE model database, the cost of preserving forest (or the REDD payment needed to discourage forest clearing) would be higher.

However, our Social Accounting Matrix, together with FRA area data, suggests that a hectare used for crops earns 50 times more than a hectare used for forestry. This dominates the results of the CGE simulations. Small errors in measuring the contribution of forestry are almost irrelevant in this context.

[13] Imagine that 0.4 cleared hectares yields 16 (=40*0.4) logs, while 99.6 remaining hectares yield 99.6 logs.

[14] The "appropriate adjustments" would need to take into account that the Churia forest is larger, and disappearing at a slower rate, and that in the Hills the deforestation rate is lower still. So our over-estimate of the sustainable contibution of forests is probably less than 13.8%.