International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 9, Issue 9, 2017, pp.-3925-3929.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

ECO-ENVIRONMENTAL ANALYSIS OF IMPLEMENTING REDD+ IN INDIA: COST AND BENEFIT APPROACH

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Received: January 14, 2017; Revised: February 02, 2017; Accepted: February 05, 2017; Published: February 24, 2017

Abstract- The Global warming is one of the most important issue worldwide. The primary cause of global warming is taken to be the burning of oil and gas. But according to IPCC reports, major amount of GHG released in the atmosphere each year is caused by deforestation and forest degradation in tropical regions. It is the second largest source of global greenhouse gas (GHG) emissions. Carbon Sequestration which is defined as the ability of the trees to capture carbon from the atmosphere, is a natural combat for these harmful emissions. So, forests play a very important role in carbon sequestration. The more forests we have, the more carbon we can capture, and the more carbon we capture, the fewer greenhouse gases we contribute to the atmosphere. Forestry projects are very popular in the voluntary carbon market largely due to their tangible nature and characteristics like ecosystem services, conservation, and biodiversity and community benefits. One such example is REDD+. It involves creating an incentive to reduce carbon emissions by avoiding deforestation and land degradation.

In this paper, attempt is made to find the economic viability of implementing REDD+, a voluntary market mechanism which involves incentivizing developing countries to stop deforestation and forest degradation in exchange of payment by the developed countries, who wish to achieve their greenhouse gas concentration targets. Andhra Pradesh, the state with the highest deforestation rate in the country has been chosen for the study. The net revenues to the farmers from undertaking the REDD+ program and from the next best uses of forest land i.e. using the land for Rice plantation has been calculated. It was found that REDD+ comes out to be the most profitable option for the farmers of Andhra Pradesh. The effect of uncertainty was also taken into account by doing a sensitivity analysis of the results. The fact that REDD+ still came out to be highly profitable ensures that the model is efficient and robust even in case of uncertainty.

Keywords- REDD+, Cost-benefit Analysis, Sensitivity Analysis.

Citation: Sahoo Bibhu Prasad, et al., (2017) Eco-Environmental Analysis of Implementing REDD+ In India: Cost and Benefit Approach. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 9, Issue 9, pp.-3925-3929.

Academic Editor / Reviewer: Amarnath Tripathi, Bimal Kishore Sahoo, Sarangi Tapas

Introduction

Global warming is a global issue. It is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation, which trap heat inside the Earth atmosphere. Over the last 2 centuries, the concentration of CO2 in the atmosphere has increased by more than 25% since the 18th century [1]` Although most people assume that global warming is caused by burning oil and gas. But in fact, a major amount of GHG released in the atmosphere each year is caused by deforestation and forest degradation in tropical regions. It is the second largest source of global greenhouse gas (GHG) emissions. Trees are 50% Carbon, and ability of the trees to capture carbon from the atmosphere is called Carbon Sequestration. So, forests play a very important role in Carbon Sequestration. The more forests we have, the more carbon we can capture, and the more carbon we capture, the fewer greenhouse gases we contribute to the atmosphere. Due to the growing levels of global warming in the atmosphere, a lot of efforts have been made in order to include the forestry sector so as to reduce the GHG concentrations into the atmosphere. This sector can contribute significantly to reduce global CO2 emissions through deforestation, and can also provide opportunities to lessen the levels of CO2 in the atmosphere by sequestering it in soils and vegetation as well as in wood products. In this way the forestry sector can play a critical role in stabilizing global CO2 concentrations [6]. Creating a market for such solutions is of prime importance in this regard.

Market based solutions in case of environmental problems involve creating a market for using the environment and making the beneficiary pay for it. A number of ways can be used by the government in order to set a price on the use of environment, e.g. setting a tax on pollution emitted by firms, selling pollution permits to firms at a set price and creating an emissions trading market. An emissions trading market involves a compliance and a voluntary market. Voluntary markets also act as an alternative enabling businesses, governments, NGOs, and individuals to reduce their emissions by purchasing credits that are created in the voluntary market. These markets are not legalized by the legislation and are undertaken voluntarily to meet their emission targets and make money. Although it is smaller than the compliance market, it is said to have great potential in reducing the greenhouse gases [15] Forestry projects are very popular in the voluntary carbon market largely due to their tangible nature and characteristics like ecosystem services, conservation, and biodiversity and community benefits [5]. One such example is REDD+. It involves creating an incentive to reduce carbon emissions by avoiding deforestation and land degradation. It is an international system of Payment for Ecosystem Services (PES). PES can be defined as voluntary and conditional transaction between at least one buyer and one seller for a well-defined environmental service. It has the potential to implement effective and cost efficient instrument for implementing REDD+ on ground. The economics behind this is that the economic value of the carbon REDD+ saves has to exceed the total cost of providing the environmental service [15]

REDD+: Coming to the definition of REDD+ it was adopted by United Nations Framework Convention on Climate Change (UNFCCC) at Bali in December, REDD is a United Nations initiative for Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries. The Programme is built on the technical expertise of the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP) and the United Nations Environment Programme. It is basically an effort to create a financial value for the It is basically an effort to create financial carbon stored in forests, offering incentives for the developing countries to decrease emissions from forested lands and to invest in low carbon paths to sustainable development. The concept of REDD+ was born during the 29th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA) in Pozan, COP14, 2008. It goes beyond REDD by including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. Standing forests also conserve carbon while supporting the livelihoods of a large number of Indigenous People and forest-dependent communities as well providing essential ecosystem services such as habitat for biodiversity and provisioning clean water supplies. REDD+ can be seen as one of the most cost-effective ways of stabilizing the atmospheric concentration of greenhouse gas (GHG) emissions to avoid a temperature rise. It offers a compelling strategy for climate change mitigation because of its potential to quickly reduce carbon emissions at a relatively low cost, while providing compensation for local forest users [12]. The REDD+ approach incorporates important benefits of livelihoods improvement, biodiversity conservation and food security services [14]. It provides opportunities for interaction between governments, civil society organizations and technical experts, to ensure that REDD+ efforts are based on science and take into account the views and needs of all stakeholders.

INDIA AND REDD+:

The Forest Survey of India (FSI) defines a forest as 'all the lands, more than one hectare in area, with a tree canopy density of more than 10%'. According to the State of Forest Report 2011, area under forests in India is estimated to be 69.20 m ha(during 2009), making up 21.02% of the total geographical area of the country. In India, forest policies and programes have significantly contributed to the reduced rates of deforestation, increased a forestation and overall stabilization of area under forests [13]. India is therefore one of the few countries where forest cover has stabilized.

Approximately 200 million people in India are dependent on forests for their livelihood [14]. India stands to gain a lot from REDD+ as it has opened avenues to get compensation for conservation of forests, which will result in increase of forest cover and consequently reduce forest carbon stocks. The incentives which will be received from REDD+ would be passed on to the local communities which are involved inforest conservation. the next 30 years and will gain US$ 3 billion as carbon service incentives [14].The REDD+ initiative will be beneficial for the local Indian communities as it clearly safeguards their rights. The monetary benefits from REDD+ will flow to local, forest dependent, forest-dwelling and tribal communities. It advocates a comprehensive approach to REDD which has been termed as a REDD Plus approach. This approach argues for compensating countries not only for 'reducing deforestation' but also for 'conservation, sustainable management of forest and increase in forest cover'. Though India has only 12% of the global forest area, it is faced with the demands of 16% of the world's human and 18% of world's cattle population. Despite these pressures, India has been able to maintain its forest cover and address the issues of deforestation. However, unsustainable exploitation of forest resources has resulted in the degradation of the forests which has been estimated at 40% for the past two decades [1]. As per the REDD IGES database, 34 REDD projects are registered from all over the world from different countries. India has 1 project registered, namely "Umiam Sub-watershed REDD+ Project, East Khasi Hills District Meghalaya, India" The project area is situated in the Central Plateau Upland region of the state of Meghalaya, and is characterized by great diversity. The main target of the programme are the community people dependent on the forests for their livelihood by helping in developing new income generating activities that address poverty and help control local drivers of deforestation. They are expected to benefit from the program in form of technical assistance and capital for conservation and restoration techniques, self-help groups for women to help them engage in other income generating activities etc. As per a study by [4], the project is expected to earn between US$ 42000-80000 a year.

The paper here tries to study the cost benefit analysis of implementing REDD+ in Andhra Pradesh, the state with 23% of its geographical area under forest cover. Andhra Pradesh was responsible for the high levels of deforestation in India, it makes it a good site to implement REDD+. Not only would implementing REDD+ help curb the high rates of deforestation in the state, but would also help the farmers by providing them an extra source of income.

Literature Review

Nilsson and Schopfhauser[10] analyzed the changes in the carbon cycle that could be attained with a global a forestation program which is economically, politically, and technically feasible. It estimated that of the areas regarded as suitable for large-scale plantations, only about 345 million ha would actually be available for plantations and agro forestry for the sole purpose of sequestering carbon.

A study on South America by Koning et al [8] found out that around 20000 ha of land in Ecuador and Argentina can be reforested to generate about 30 million carbon credits. The study showed carbon sequestration in above-ground biomass and soils of plantation forests and secondary forests in two countries in South America-Ecuador and Argentina-and calculated costs of temporary carbon sequestration. Costs per temporary certified emission reduction unit varied between 0.1 and 2.7 USD Mg-1 C02 and mainly depended on opportunity costs, site suitability, discount rates, and certification costs. In Ecuador, secondary forests came out to be a feasible and cost-efficient alternative, whereas in Argentina reforestation on highly suitable land was relatively cheap.

Karky and Skutsch [7] in their paper 'The Cost of carbon abatement through community forest management in Nepal Himalaya' have estimated the economic returns to carbon abatement through biological sequestration in community managed forest under future REDD policy and were compared for possible management scenarios. The data was collected from forest users in 3 sites of Nepal: Ila, Lamatar and Manang and other forestry data was used. The methodology adopted includes the IPCC Good practices guidelines. The management of the land is done by Community forests user groups (CFUGs). To estimate the cost of carbon sequestration in forested land, 3 different scenarios were established. Scenario 1 was no change scenario. The benefits derived in this case were fuel, wood, fodder, timber and non-timber forest products (NTFPs) while the cost include labour, day-to-day management and operation costs, and forest protection work. Scenario 2 was where communities continue to meet their subsistence needs and at the same time sell credits. The additional benefits here include carbon revenue derived from forests, for which rates of $1 and $5 per ton CO2 were used for the sake of the calculations. Additional cost in this scenario includes carbon stock measurement preparation of the project proposal/ documentation, marketing of credits, adoption of a more formal management system.

Plum et al [12] in their paper 'Challenges of Opportunity cost analysis in planning REDD+: A Honduran case study of social and cultural values associated with Indigenous forest uses' have assessed the opportunity cost associated with an indigenous community's forest uses in Hondura's Rio Platano Biosphere reserve. Data was collected on quantitative information about demographics, land use, agricultural activities and forest products using household surveys, farm visits and community workshops. The crops namely rice, beans, corn, bananas, plantains and yucca were assumed to be planted there. Total economic value of all agricultural products was calculated by multiplying production in each crop type by its respective market price which was then summed and divided by total hectares planted to get an estimate of the annual return per hectare. The results showed that the opportunity cost for slowing deforestation from agriculture ranges from 2-7$/t$CO_2$ and even less for other forest uses. Since these are within the range of voluntary carbon market prices, it provided an economic justification for development of the REDD+ project.

Objective

The objective of the study conducted here is to calculate the net benefit from implementation of REDD+ program in Andhra Pradesh and compare it with the opportunity costs of implementation that is net forecasted profit from rice cultivation in the state. The paper attempts to calculate the economic viability of implementation of the program in India.

Hypothesis

$$H_0 = \text{farmer is indifferent between implemetation of REDD} + \text{and rice cultivation}$$

$$H_A = \text{implementation of REDD} + \text{is better than rice cultivation for the farmer}$$

Methodology and Data

For this study, a Cost Benefit Analysis (CBA) is carried out to compare the costs and benefits of implementing REDD+ and then to decide upon whether such a program is beneficial for the farmers of AP. It is the most common method of economic project and policy appraisal. It is a decision tool which judges projects according to a comparison between their costs (disadvantages) and benefits (advantages). If a project shows a net benefit, it can be approved, and different projects can be ranked according to the size of their net benefit.
Therefore, a project or policy is accepted if:

[Benefits - Costs] > 0 [2]

Here, Costs will be captured by calculating the net revenues from alternative land uses i.e. Rice Cultivation, which represent the opportunity costs of conserving forests, and benefits will be captured by calculating the net revenues that the farmers will receive by conserving forests and selling carbon credits in the carbon market. To calculate the net revenues to farmers from different land use options, this study follows the methodology from Bann, 1997 [2]
In this paper we calculate the total Economic value of land used for agriculture as:

Total Economic value = Efficiency Price * Maximum sustainable yield – Harvest Cost ...[1]

To calculate the revenue from conserving forests, price per ton CO2 i.e. the price of a carbon credit will be multiplied by the Carbon content of forest:

Total Revenue = Price/tCo2 * Forest Carbon (Gupta, 2013)...................... .....[2]

To compare the benefit and cost from the implementation of REDD+, the benefit from implementation, defined as the benefit from conserving carbon is compared with net profit that farmers will gain from rice cultivation for next 10 years (which is cost of REDD+). For this forecasted value of net profit is discounted to attain the present value of net profit achievable by farmers as in 2015 from rice cultivation at different discount prices. Different discount prices are taken there is uncertainty in the agriculture in India, which is very high. Hence higher values of discount rates are undertaken.
Finally analysis is done to compare the benefit received and opportunity cost of implementing REDD+ in Andhra Pradesh.

Data

On forest carbon is extracted from Report of Forest Survey of India, where the data for carbon for the year 1994, 2004, 2011 and 2013 was available for all over India. Since the data for Andhra Pradesh was given only for the year 2004, attempt has been made to calculate the growth rate of carbon stock at all India level, using Log model, which came out to 0.5032% per annum. Then this growth rate has been use to forecast the value of carbon stock in Andhra Pradesh for the year 2015, the year under study. The following table [Table-2] shows the forecasted value of carbon in the state at the calculated growth rate.
This is multiplied by the price carbon. The price of carbon is determined internationally in euros. The value has been multiplied by the exchange rate between euro and rupees and then the figure is calculated. This provided us with the total benefit achieved from REDD+ implementation in the state.

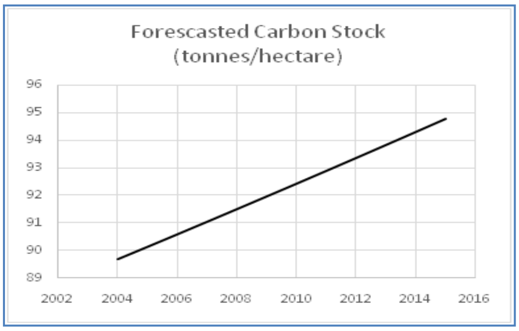

Fig-1 Forecasted Carbon Stock from 2004 to 2015 for State of Andhra Pradesh

Table-1 *Forecasted Carbon Stock from 2004 to 2015 for State of Andhra Pradesh*

year	Forecasted Carbon Stock (tonnes/hectare)
2004	89.7
2005	90.15135312
2006	90.60497735
2007	91.06088414
2008	91.51908496
2009	91.97959136
2010	92.44241494
2011	92.90756736
2012	93.37506034
2013	93.84490565
2014	94.31711513
2015	94.79170068

Source: Author own table

The data on rice yield, market price of rice and price of cultivation is extracted from Directorate of Economics and Statistics, various reports. To calculate the cost of implementing REDD+ in state, net profit from other alternative that the land can be used for is, that is rice cultivation in our study, is calculated. To do the cost and benefit analysis we required the benefit the farmers will attain if they sell the carbon credits in the voluntary market *today,* today defined as in 2015, we henceforth need the net profit from rice cultivation *today.* For this net profit from rice cultivation is forecasted for the next 10 years, that is, from 2005 to 2015. Then these net profits calculated for the next decade has been discounted to attain present value of profit from rice cultivation. Here we assume that a farmer will continue to cultivate rice for at least 10 years and so the discounted values are undertaken. Also, attempt has been made to calculate the profit from rice cultivation at different discount rates, for sensitivity analysis. High discount prices undertaken shows persistence of high level of uncertainty in Indian agriculture sector. The harvest price in each year is increased by a factor of 0.5% owing to the increase in cost of cultivation over the years. Summary statistic of the variable undertaken are shown in the [Table-3].

Table-2 *Summary statistics*

Particulars	Min	Max	Average	Standard Deviation
Carbon Stock (tonnes/hectare)	91.91	100.93	97.42	4.15
Carbon Emission Price (Euro / tonnes)	7.05	8.71	7.84	0.57
Exchnage Rate (Rs/Euro)	68.23	76.60	71.29	2.45
Rice Yield(Kg/H)	2891.00	3344.00	3093.30	140.19
Price of Harvest(Rs/Qt)	1209.00	2841.00	1816.90	521.71
MSP(Rs/Qt)	560.00	1310.00	918.00	267.24

Source: authors own able

Economic Model

Following the above methodology, we calculate the Net Present Value (NPV) of net revenue streams associated with each land use as an economic indicator to estimate the profitability of each identified land use. An economic model predicts the net present value of marketed goods and services from the landscape for a given land-use pattern. The net present value of revenue from each land use on parcel (j) depends upon productivity of the land use on the parcel, the price of the produce, and production costs. So the objective function will be given by:

Max π= (P.Q. – C) / (1+ r)^t … (1) W.r.t. Q **[3]**

Profit is a concave function i.e.π ' (.) > 0 and π" (.) < 0 **[11]**

Where, P is the price, Q is the quantity of output, C is the cost, r is the discount rate and t is the time period.
On maximizing the above equation, we get our first order condition as:

$$\partial\pi/_{\partial Q} = \frac{P-C(Q)}{(1+r)^t} = 0 \quad [4]$$

Or,

Present Discounted Marginal Revenue = Present Discounted Marginal Cost
That is, we aim to maximize the net present value of the net revenues to farmers from different land use. Farmers will produce up to the point where their marginal revenue equals their marginal cost.

Econometric Model

For the purpose of forecasting, an Autoregressive Integrated Moving Average (ARIMA) model popularized by Box and Jenkins is used for the study. Starting with identification, the first step in any time series analysis is to check for stationarity. The Augmented Dickey Fuller (ADF) test is conducted on all the variables to derive accurate conclusions on unit roots of the series. After the identification step, comes the estimation step. Here, tentative models based on the identification step are presented and checked for their suitability. After the diagnostic check, we arrive at the best fit model for the series. Forecasts are then made using the final model.

Results

The result of the methodology explained above, elaborated in the following table

Table-3 *benefit from REDD+*

Carbon stock in AP in 2015	94.79 tonne/hectare
Price per carbon credit in world market	558.88 Rs/tonne
Total revenue from selling the carbon credit under REDD+	***Rs. 52977.36 rs./hectare***

The [Table-2] shows that from the calculated growth rate of 0.5032% per annum, the forecasted carbon stock in Andhra Pradesh is equal to 94.79 tonne per hectare. Given the price of carbon in the world market being equal to Rs. 558.88 per tonne, the total revenue from selling the carbon credits is equal to Rs. 52977.36 per hectare.

Table-4 *Costs for REDD+ or net profit from rice cultivation*

Discount Rate	Cost of REDD+ (Rs/Hectare)
25	47,371.72
26	45,397.64
27	43,541.98
28	41,796.13
29	40,152.19
30	38,602.92
31	37,141.65
32	35,762.27
33	34,459.15
34	33,227.10
35	32,061.34
22.46	**52977**

The [Table-4] depicts the net present value of forecasted profit from rice cultivation for the AP farmers from 2015 to 2025 at different discount rates. It can be seen as the discount rates are increased, the net profit from rice cultivation falls in present discounted value.
Now at these different discount rates, the net benefit from implementing REDD+ is calculated and shown in [Table-5].
The [Table-5] clearly shows that the null hypothesis, that the farmer is indifferent between cultivating rice on the field or letting the forest stay on his land is when the discount rate is 22.46%. At discount rate above 22.46%, there is clear benefit from implementation of REDD+ in the state. If farmer sells the carbon credit of his land in the international market under REDD+ scheme, he will earn more than him cultivating rice on his land. We can make such strong conclusion as discount rates in agriculture tend to be high due to high level of uncertainty in the agriculture sector.

Table-5 *Benefit minus cost of implementing REDD+ a different discount rates*

Discount Rate	Cost of REDD+ (Rs/Hectare)	Benefit from REDD+ (Rs/hectare)	Net Benefits (benefit-cost) (Rs/Hectare)
25	47,371.72	52977.36	5,605.65
26	45,397.64	52977.36	7,579.73
27	43,541.98	52977.36	9,435.38
28	41,796.13	52977.36	11,181.23
29	40,152.19	52977.36	12,825.17
30	38,602.92	52977.36	14,374.45
31	37,141.65	52977.36	15,835.71
32	35,762.27	52977.36	17,215.09
33	34,459.15	52977.36	18,518.21
34	33,227.10	52977.36	19,750.27
35	32,061.34	52977.36	20,916.03
22.46	**52977**	52977.36	**0**

Conclusion

Indian agriculture sector is vulnerable compared to other countries. The huge dependency on monsoon and climatic conditions creates high degree of uncertainty in the sector. Purpose of this paper was to check for the economic viability of implementing REDD+ inAndhra Pradesh. Different land use options i.e. Agriculture in the form of Rice plantation,Timber plantation and Conserving forests were assessed. Net revenues from conserving forests came out to be the highest. The results were also checked for efficiency and robustness by carrying out a sensitivity analysis using three different discount rates. Thus, it was found that Andhra Pradesh serves to be a good site for implementing REDD+ in the future 10 years. Although many countries have shown that REDD+ tends to alienate the farmers from their own lands and that is why there is a lot of resistance from farmers with respect to implementing this scheme, the solution to this problem lies in the fact that since farmers are not well aware of the working of REDD+ and are kept outside the boundary of project designing, it develops a fear of losing their lands among the farmers. Thus the need of the hour is that farmers should be made aware of the program through campaigns and proper training and should be done to show them how farmers from other countries have benefitted from such programs. Although it should not be the case that farmers are completely barred from carrying out their regular agricultural activities, as agriculture is the major occupation of the farmers, instead they should be discouraged from carrying out deforestation for agriculture or any other activity and should be made aware of the revenue that that they would instead get from keeping the forests intact. This would then prove beneficial not only for the farmers, but also the developed countries to achieve their emission targets.

Acknowledgement: Author are thankful to SGTB Khalsa College, University of Delhi for cooperating during the research

Funding: author's own

Abbreviations:

- NVP- net present value

- ARIMA- autoregressive integrated moving averages
- ADF- augmented dickey fuller test
- AP- Andhra Pradesh

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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