PalArch's Journal of Archaeology of Egypt / Egyptology

INTEGRATED ASSESSMENT OF THE ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACT OF SOME PROJECTS OF CONVERTING DIPTEROCARP FOREST TO RUBBER PLANTATION IN TERRITORY OF DAK LAK PROVINCE, VIETNAM

Phung Chi Sy[1], Vu Thanh Nam[1], Phung Phuong Anh[2], Phan Cong Chinh[3], Hoang Huu Dung[1]*

[1]Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam

[2]Environmental Technology Centre (ENTEC), Ho Chi Minh City, Vietnam

[3]The People's Security Universitym, Ho Chi Minh City, Vietnam

* Corresponding author: [1]entecvn.pcsy@gmail.com

Phung Chi Sy, Vu Thanh Nam, Phung Phuong Anh, Phan Cong Chinh, Hoang Huu Dung. Integrated Assessment Of The Economic, Social And Environmental Impact Of Some Projects Of Converting Dipterocarp Forest To Rubber Plantation In Territory Of Dak Lak Province, Vietnam--Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(4), 454-469. ISSN 1567-214x

Keywords: Economic, Social And Environmental, Dipterocarp Forest, Rubber Plantations

ABSTRACT

Using actual survey data and a developed system of parameters and indices to assess the economic, social and environmental impacts for the projects of converting dipterocarp forests to rubber plantations in the territory of Dak Lak province, results for the absolute and relative indices for assessing the economic, social and environmental impacts, and an aggregate assessment were calculated for the 3 selected projects of converting dipterocarp forests to rubber plantations. These findings showed that the absolute aggregate impact index of Phuoc Hoa Rubber Joint Stock Company is 48, Phat Dat Private Enterprise is 50 and Duc Tam Co., Ltd is 37; whereas the relative aggregate index of Phuoc Hoa Rubber Joint Stock Company is 175, Phat Dat Private Enterprise is 179, and Duc Tam Co., Ltd is 134. When compared with the index rating, it shows that the projects of Phuoc Hoa Rubber Joint Stock Company and Phat Dat Private Enterprise have medium possitive impacts, the project of Duc Tam Co., Ltd have low possitive impacts. Therefore, it is recommended that Phuoc Hoa Rubber Joint Stock Company and Phat Dat Private Enterprise should review whether to continue the projects of converting dipterocarp forest to rubber plantations in Dak Lak province by reviewing the parameters which have not met targets; while Duc Tam Co., Ltd should stop their projects of converting dipterocarp forests to rubber plantations.

INTRODUCTION

Updated information of rubber plantations is essential for assessing socioeconomic and environmental impacts, especially in the emerging region of northern tropics. Accurately monitoring rubber plantations dynamics is essential for assessing eco-environmental effects in soil, hydrology and biodiversity especially in the northern edge of the Asian tropics (e.g. Dak Lak province, Vietnam) [1-20].

On 03rd June 2009, The Prime Minister has issued Decision No 750/QĐ-TTg on approving the master plan for rubber development up to 2015 and vision to the year 2020; with goals to develop about 95,000-100,000 hectares of rubber plantations in Tay Nguyen from 2010 to 2015 on the less productive agricultural lands, unused lands, as well as converting natural forests of poor production forest for rubber trees planting [21]. As a result, on 20 October 2014, the People's Committee of Dak Lak Province has issued Decision No.2456/QĐ-UBND to approve the master plan for development of rubber trees 2014-2020 [22]. In accordance to the planning scheme for development of rubber plantations from 2014 to 2020, the total area of provincial rubber plantations is expected to increase to 66,800 ha by 2020, in which the total area of 29,829 ha for rubber plantation development scheme in Buon Don, Ea Sup, Cu M'Gar and Ea H'leo districts where are particularly having Dipterocarp forests [22]. Most of the surveyed areas for the projects are forest land, including 40,254 hectares of natural forests.

By August 2014, 30 projects were implemented with 7.615 hectares of rubber plantation across the province. According to the report of Dak Lak's Department of Agriculture and Rural Development, by May 2017, there are currently 28 projects in the province, of which 7,462.92 hectares have been planted [23]. Many difficulties and inadequacies have occurred during the process of converting dipterocarp forests to rubber plantation; which has led to low economic, social and environmental efficiency. To continue the planning scheme for rubber development on dipterocarp forest lands, it is necessary to conduct a comprehensive evaluation for the implemented projects to provide scientific basis and practices to come up with corrective measure [24-28].

To provide an aggregate impact assessment for the projects of converting dipterocarp forests to rubber plantations, a system of 27 parameters and indices for economic, social and environmental impact assessment were developed [29]. This article presents the results of "Development of parameter, index system for economic, social and environmental impact assessment of converting Dipterocarp forest to rubber plantations in Dak Lak province, Vietnam" based on the system of parameters, indices which were previously developed.

MATERIALS AND METHODS

Selecting 3 projects of converting of poor forest to rubber plantation

To assess the economic, social and environmental performance for the projects of converting dipterocarp forests to rubber plantations in the territory of Dak Lak

province, the authors have selected three projects for demonstration. The selection criterias include: the projects of converting dipterocarp forests to rubber plantations have: relatively large area; different ownership forms (state, private); different levels of development (good, average, poor); relatively same project implementation time; similar natural, economic and social conditions. Based on the above principles, the authors have selected three projects as shown in **Table 1.**

Methods of information collection to assess the impacts for projects of converting low-production Dipterocarp forests to rubber plantation

- Method of interviewing stakeholders: During the research, the authors have designed interview forms and conducted interviews at the site of 3 selected projects and vicinity areas, including in-depth interviews with target groups of officials of Ea Sup district, Ea Le, Cu M'Lan, Ea Bung & Ya To Mot commune, a member of 03 rubber plantation projects, local people involved in 03 forest conversion to rubber plantation projects.

- Method of survey, field survey:The authors conducted field surveys and recorded data at the rubber plantation sites on the converted forest land of 03 selected companies (Phuoc Hoa Rubber Joint Stock Company, Phat Dat Private Enterprise, Duc Tam Manufacturing - Trading - Construction Co., Ltd).

Method of impact assessment for projects of converting low-production Dipterocarp forests to rubber plantation

The authors have developed a system of parameters for economic impacts (10 parameters), for social impacts (7 parameters), for environmental impacts (10 parameters). The assessment scores for each parameter are 1 (low possitive impact), 2 (medium possitive impact), 3 (high possitive impact). The impact assessment indices for each projects of converting Dipterocarp forests to rubber plantations include: Economic Impact Assessment Index (EcI); Social Impact Assessment Index (SoI); Environmental Impact Assessment Index (EnI). The Aggregated Impact Assessment Index (ESEI) of converting dipterocarp forests to rubber plantations is calculated by integrating the impact assessment indices of all 3 components (EcI, SoI, EnI)[4].

The calculation process can use absolute indices (Table 2) or/and relative indices in percentage terms between each absolute index over the maximum index (Table 3) (For example, the Economic Assessment Index is 15, the maximum index is 30, so the relative index would be (15/30) x100 = 50).

RESULTS AND DISCUSSIONS

The results of economic impact assessment for 03 projects according to the developed parameters

Data about the economic impacts of 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province are presented in Table 4. Based on a set of economic impact assessment criterias for the implemented projects of converting dipterocarp forests to rubber plantations [4], the economic impacts of 03 projects can be assessed like in **Table 5.**

The results when compared with the absolute index of the economic sector in Table 2 have shown that Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) have medium economic possitive impacts, the project of Duc Tam Co., Ltd (Project 3) has low possitive impacts. Therefore, Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) should review whether to continue the projects of converting dipterocarp forests to rubber plantations on the basis of reviewing the parameters which have not met targets. Duc Tam Co., Ltd (Project 3) should stop implementing the projects of converting dipterocarp forests to rubber plantations.

The results of social impact assessment for 03 projects according to the developed parameters

Data about the social impacts of 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province are presented in Table 6.
Based on a set of social impact assessment criterias for the implemented projects of converting dipterocarp forests to rubber plantations [4], the social impacts of 03 projects can be assessed like in **Table 7**.

The results when compared with the absolute index of the social sector in Table 2 have shown that Phuoc Hoa Rubber Joint Stock Company (Project 1) has medium social possitive impacts, the projects of Phat Dat Private Enterprise (Project 2) and Duc Tam Co., Ltd (Project 3) have low possitive impacts. Therefore, Phuoc Hoa Rubber Joint Stock Company (Project 1) should review whether to continue the projects of converting dipterocarp forests to rubber plantations, on the basis of reviewing the parameters which have not met targets. Phat Dat Private Enterprise (Project 2) and Duc Tam Co., Ltd (Project 3) should stop implementing the projects of converting dipterocarp forests to rubber plantations.

The results of environmental impact assessment for 03 projects according to the developed parameters

Data about the environmental impacts of 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province are presented in Table 8. Based on a set of environmental impact assessment criterias for the implemented projects of converting dipterocarp forests to rubber plantations [4], the environmental impacts of 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province can be assessed like in **Table 9.**

The results when compared with the absolute index of the environmental sector in Table 2 have shown that Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) have medium social possitive impacts, the project of Duc Tam Co., Ltd (Project 3) has low possitive impacts. Therefore, Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) should review whether to continue the projects of converting dipterocarp forests to rubber plantations, on the basis of reviewing the parameters which have not met targets. Duc Tam Co., Ltd (Project 3) should stop implementing the projects of converting dipterocarp forests to rubber plantations.

Result of the aggregated impact assessment for 03 projects according to the established indices

The results of assessing the economic, social and environmental impacts for 03 projects, selected in accordance to the system of economic, social and environment criteria [4], are presented in Table 10. For a relative comparability of the projects, it is possible to convert from the absolute index to the relative index of each project as shown in the Table 11. Integrated assessment results according to the set of economic, social and environmental indices for 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak is visually presented in Figure 1-3.

The results when compared with the absolute aggregate index rating in Table 2 and the relative aggregate index rating in Table 3 show that the project of Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) have medium possitive impacts, the project Duc Tam Co., Ltd (Project 3) have low possitive impacts. Therefore, Phuoc Hoa Rubber Joint Stock Company (Project 1) and Phat Dat Private Enterprise (Project 2) need to review whether to continue the projects of converting dipterocarp forest to rubber plantations in Dak Lak province, on the basis of reviewing the social, economic and environmental parameters which have not met targets. Duc Tam Co., Ltd (Project 3) should stop implementing the projects of converting dipterocarp forests to rubber plantation.

Table 1. Information about 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province

No	Criteria	Project 1	Project 2	Project 3
01	Investor	Phuoc Hoa Rubber Joint Stock Company	Phat Dat Private Enterprise	Duc Tam Trading-Manufacturing-Construction Co., Ltd
02	Form of ownership	State-owned enterprises	Private enterprise	Private enterprise
03	Location of project	Ea Le Commune, Ea Sup District	Cu M'Lan commune, Ea Sup district	Ea Bung & Ya To Mot commune, Ea Sup district
04	Planned area of rubber plantations (ha)	983.69	294.89	854.00
05	Area of rubber trees planted (ha)	166.35	200.00	35.00
06	Start time of planting	2012	2008	2010
07	Total estimated investment (VND)	155,472,300,000	16,475,000,000	99,652,948,000
08	Investment funds as of 2017 (VND)	90,000,000,000	15,500,000,000	1,.950,000,000
09	Situation of rubber tree growth	- Constantly changing land along with thin layer of cultivation soil. Thus, the rubber planting area is less than the total area. - In rubber growing areas, plants grow well, especially since the time of planting, there has been	- In 2010, started to plant rubber in the trial area of 100 ha according to the initial approval of the project; - The company self-reclaimed and planted more 100 ha, but not yet established the conversion procedures according to the law. In the first 2-3 years, beans, corn, wheat were intercropped with well-grown rubber tree, have started to harvest latex from 2016.	In 2015, 65 ha of the rubber plantation were burnt (damage 70% of the trees planted), the rest grow unevenly, high rate of mortality due to lack of investment and care.

		no diseases, since the intensity of light here is quite high. - Rubber trees have been growing well or exceeding standards of the Vietnam Rubber Group. -It is expected that latex would be extracted from trees after 7 years of planting		

Table 2. Absolute index rating for assessing social, environmental economic impacts and integrated assessment index

No	**Assessment rating**	Economic Impact Assessment Index	Social Impact Assessment Index	Environmental Impact Assessment Index	Aggregated socio-economic and environmental impact assessment index
1	Low	10-15	7-10	10-15	27-40
2	Medium	16-25	11-14	16-25	41-64
3	High	26-30	15-21	26-30	65-81

Table 3. Relative index rating for assessing social, environmental economic impacts and integrated assessment index

No	**Assessment rating**	Economic Impact Assessment Index	Social Impact Assessment Index	Environmental Impact Assessment Index	Aggregated socio-economic and environmental impact assessment index
1	Low	33-50	33-48	33-50	99-148
2	Medium	51-83	49-67	51-83	151-233
3	High	84-100	68-100	84-100	236-300

Table 4. Data about the economic impacts of 03 projects of converting dipterocarp forests to rubber plantations

Symbol	Parameters	Unit	Project 1	Project 2	Project 3
Ec-01	Investment rate of project	Million VND/ha	91.5	77.5	119.5
Ec-02	Compensation for people	Million VND/ha	0	40.0	0
Ec-03	Cost of converting forest land to rubber plantation	Million VND/ha	31.0	30.8	27.2
Ec-04	Cost of labor	Million VND/ha/year	15.6	8.1	6.2
Ec-05	Cost of fertilizer, pesticides	Million VND/ha/year	16.9	8.3	7.1
Ec-06	Investment cost of irrigation system	Million VND/ha	30.0	30.0	10.0
Ec-07	Income from rubber harvest	Million VND/ha/year	0	5.3	0
Ec-08	Income from non-rubber harvest	Million VND/ha/year	0	78.0	0
Ec-09	Net Present Value (NPV)	%	<0	<0	<0
Ec-10	Payback period	Year	10	10	20

Table 5. Economic impact assessment scores for 03 projects of converting dipterocarp forests to rubber plantations

Symbol	Parameters	Assessment score		
		Project 1	Project 2	Project 3
Ec-01	Investment rate of project	2	2	3
Ec-02	Compensation for people	1	2	1
Ec-03	Cost of converting forest land to rubber plantation	2	2	1
Ec-04	Cost of labor	2	1	1
Ec-05	Cost of fertilizer, pesticides	3	2	2
Ec-06	Investment cost of irrigation system	2	2	1
Ec-07	Income from rubber harvest	1	1	1
Ec-08	Income from non-rubber harvest	1	3	1
Ec-09	Net Present Value (NPV)	1	1	1
Ec-10	Payback period	3	3	1
	Total	***18***	***19***	***13***

Table 6. Data about the social impacts of 03 projects of converting dipterocarp forests to rubber plantations

Symbol	**Parameters**	**Unit**	**Project 1**	**Project 2**	**Project 3**
So-01	Number of jobs created for people	People	90	60	13
So-02	Number of jobs created for ethnic people	People	30	0	0
So-03	Amount contributed to roads construction	Million VND/year	0	0	0
So-04	Amount contributed to schools building	Million VND/year	0	0	0
So-05	Amount contributed to hospitals building	Million VND/year	0	0	0
So-06	Number of disputes over land	No. of disputes	Disputes occured, and not resolved	Disputes occured, but already resolved	Disputes occured, but already resolved
So-07	Number of people trained and raised awareness about rubber plantation	People	80	60	0

Table 7. Social impact assessment scores for 03 projects of converting dipterocarp forests to rubber plantations

Symbol	**Parameters**	**Assessment score**		
		Project 1	**Project 2**	**Project 3**
So-01	Number of jobs created for people	2	2	1
So-02	Number of jobs created for ethnic people	2	1	1
So-03	Amount contributed to roads construction	1	1	1
So-04	Amount contributed to schools building	1	1	1
So-05	Amount contributed to hospitals building	1	1	1
So-06	Number of disputes over land	1	2	2
So-07	Number of people trained and raised awareness about rubber plantation	2	2	1
	Total	***11***	***9***	***8***

Table 8. Data about the environmental impacts of 03 projects of converting dipterocarp forests to rubber plantations

Symbol	Parameters	Unit	Project 1	Project 2	Project 3
En-01	Area of natural forest destroyed	Ha	400	81	100
En-02	Area of Dipterocarp forest destroyed	Ha	400	81	100
En-03	Adaptation to local soil conditions	Level	S2	S2	S3
En-04	Adaptation to local meteorological conditions	Level	Medium adaptation	Medium adaptation	No adaptation
En-05	Number of harmed wildlife species	No. of species	All	All	All
En-06	Rate of collected, processed vegetation	%	100	100	100
En-07	Rate of collected, processed domestic solid waste	%	50	50	50
En-08	Rate of collected, processed fertilizer, pesticides packaging bags	%	100	100	0
En-09	Rate of collected, processed domestic wastewater	%	100	100	0
En-10	Level of coverage	%	90	80	20

Table 9. Environmental impact assessment scores for 03 projects of converting dipterocarp forests to rubber plantations in Dak Lak province

Symbol	Parameters	Assessment score		
		Project 1	Project 2	Project 3
En-01	Area of natural forest destroyed	1	3	2
En-02	Area of Dipterocarp forest destroyed	1	2	2
En-03	Adaptation to local soil conditions	2	2	1
En-04	Adaptation to local meteorological conditions	2	2	1
En-05	Number of harmed wildlife species	1	1	1
En-06	Rate of collected, processed vegetation	3	3	3
En-07	Rate of collected, processed domestic solid waste	2	2	2
En-08	Rate of collected, processed fertilizer, pesticides packaging bags	2	2	1
En-09	Rate of collected, processed domestic wastewater	2	2	1
En-10	Level of coverage	3	3	2
	Total	***19***	***22***	***16***

Table 10. Results of calculating the absolute index of economic, social and environmental impacts of 03 projects

No	**Project name**	Economic Impact Assessment Index	Social Impact Assessment Index	Environmental Impact Assessment Index	Aggregated socio-economic and environmental impact assessment index
1	Phuoc Hoa Rubber Joint Stock Company	18	11	19	48
2	Phat Dat Private Enterprise	19	9	22	50
3	Duc Tam Manufacturing - Trading - Construction Co., Ltd	13	8	16	37

Table 11. Results of calculating the relative index of economic, social and environmental impacts of 03 projects

No	**Project name**	Economic Impact Assessment Index	Social Impact Assessment Index	Environmental Impact Assessment Index	Aggregated socio-economic and environmental impact assessment index
1	Phuoc Hoa Rubber Joint Stock Company	60	52	63	175
2	Phat Dat Private Enterprise	63	43	73	179
3	Duc Tam Manufacturing - Trading - Construction Co., Ltd	43	38	53	134

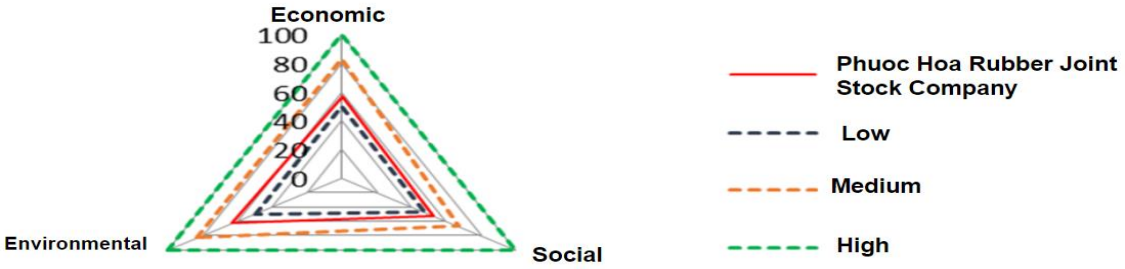

Figure 1. Results of the relative aggregate impact index for Phuoc Hoa Rubber Joint Stock Company

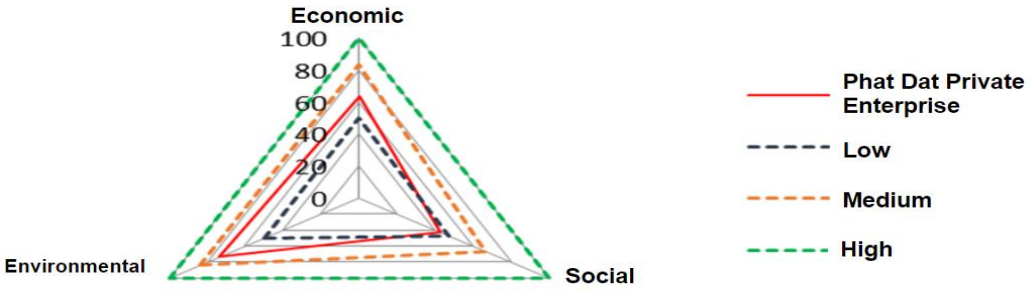

Figure 2. Results of the relative aggregate impact index for Phat Dat Private Enterprise

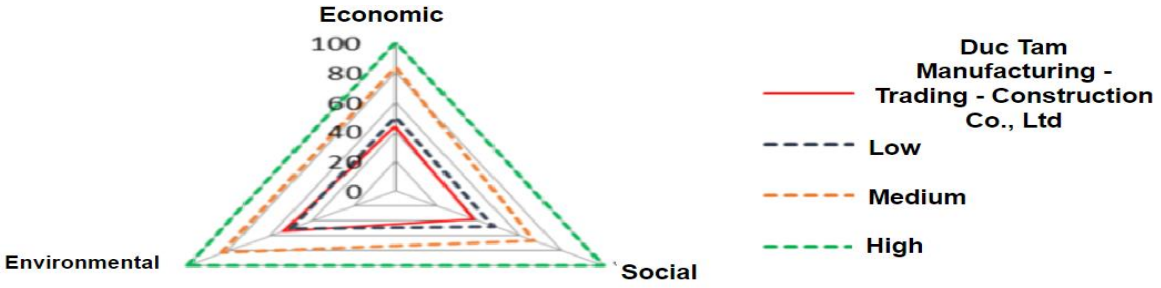

Figure 3. Results of the relative aggregate impact index for Duc Tam Co., Ltd

CONCLUSIONS

In order to assess the economic, social and environmental impacts for the projects of converting dipterocarp forests to rubber plantations in the territory of Dak Lak province, the authors have selected 3 projects by Phuoc Hoa Rubber Joint Stock Company, Phat Dat Private Enterprise, Duc Tam Manufacturing - Trading - Construction Co., Ltd.

Based on the developed system of parameters and indices to assess the economic, social and environmental impacts for the projects of converting dipterocarp forests to rubber plantations in Dak Lak province, as well as the actual survey data, the authors have presented the results of calculating the absolute and relative indices for assessing the economic, social and environmental impacts and an aggregate assessment for the 3 selected projects of converting dipterocarp forests to rubber plantations.

The results showed that the absolute aggregate impact index of Phuoc Hoa Rubber Joint Stock Company, Phat Dat Private Enterprise and Duc Tam Co., Ltd is 48, 50, 37 respectively; while the relative aggregate index is 175, 179, 134 respectively. When compared with the index rating, it shows that the projects of Phuoc Hoa Rubber Joint Stock Company and Phat Dat Private Enterprise have medium possitive impacts, whereas the project of Duc Tam Co., Ltd have low possitive impacts.

RECOMMENDATION

The authors recommend that Phuoc Hoa Rubber Joint Stock Company and Phat Dat Private Enterprise should review whether to continue the projects of converting dipterocarp forest to rubber plantations in Dak Lak province by reviewing the parameters which have not met targets; while Duc Tam Co., Ltd should stop their projects of converting dipterocarp forests to rubber plantations.

ACKNOWLEDGMENTS

The authors would like to thank Department of Science and Technology of Dak Lak province for their funding and effective cooperation during implementation of the project.

REFERENCES

Zhila Hemati, Selvaraj Selvalakshmi, Shangwen Xia, Xiaodong Yang, Identification of indicators: Monitoring the impacts of rubber plantations on soil quality in Xishuangbanna, Southwest China, Ecological Indicators, 116 (2020) Article 106491

Chiwei Xiao, Peng Li, Zhiming Feng, Monitoring annual dynamics of mature rubber plantations in Xishuangbanna during 1987-2018 using Landsat time series data: A multiple normalization approach, International Journal of Applied Earth Observation and Geoinformation, 77 (2019) 30-41.

Chiwei Xiao, Peng Li, Zhiming Feng, Zhen You, Luguang Jiang, Khampheng Boudmyxay, Is the phenology-based algorithm for mapping deciduous rubber

plantations applicable in an emerging region of northern Laos?, Advances in Space Research, 65 (2020) 446-457

Chiwei Xiao, Peng Li, Zhiming Feng, Xiaona Liu, An updated delineation of stand ages of deciduous rubber plantations during 1987-2018 using Landsat-derived bi-temporal thresholds method in an anti-chronological strategy, International Journal of Applied Earth Observation and Geoinformation, 76 (2019) 40-50

Bandana Kurmi, Arun Jyoti Nath, Rattan Lal, Ashesh Kumar Das, Water stable aggregates and the associated active and recalcitrant carbon in soil under rubber plantation, Science of The Total Environment, 70310 (2020) 135498

Su Ye, John Rogan, Florencia Sangermano, Monitoring rubber plantation expansion using Landsat data time series and a Shapelet-based approach, ISPRS Journal of Photogrammetry and Remote Sensing, 136 (2018) 134-143

Mohamad Rusdi Hidayat, Wahyu Maulana Endris, Yulia Dwiyanti, Effect of a rubber plantation on termite diversity in Melawi, West Kalimantan, Indonesia, Agriculture and Natural Resources, 52 (2018) 439-444

Gang Chen, Jean-Claude Thill, Sutee Anantsuksomsri, Nij Tontisirin, Ran Tao, Stand age estimation of rubber (Hevea brasiliensis) plantations using an integrated pixel- and object-based tree growth model and annual Landsat time series, ISPRS Journal of Photogrammetry and Remote Sensing, 144 (2018) 94-104

Chang-An Liu, Yu Nie, Xin Rao, Jian-Wei Tang, Kadambot H. M. Siddique, The effects of introducing Flemingia macrophylla to rubber plantations on soil water content and exchangeable cations, CATENA, 172 (2019) 480-487

Charongpun Musikavong, Shabbir H. Gheewala, Ecological footprint assessment towards eco-efficient oil palm and rubber plantations in Thailand, Journal of Cleaner Production, 140 (2017) 581-589

Rong Lang, Sergey Blagodatsky, Jianchu Xu, Georg Cadisch, Seasonal differences in soil respiration and methane uptake in rubber plantation and rainforest, Agriculture, Ecosystems & Environment, 2401 (2017) 314-328

Elaine Cristina Barbosa Cambui, Rodrigo Nogueira de Vasconcelos, Eduardo Mariano-Neto, Blandina Felipe Viana, Márcio Zikán Cardoso, Positive forestry: The effect of rubber tree plantations on fruit feeding butterfly assemblages in the Brazilian Atlantic forest, Forest Ecology and Management, 3971 (2017) 150-156

Jinwei Dong, Xiangming Xiao, Sage Sheldon, Chandrashekhar Biradar, Guishui Xie, Mapping tropical forests and rubber plantations in complex landscapes by integrating PALSAR and MODIS imagery, ISPRS Journal of Photogrammetry and Remote Sensing, 74 (2012) 20-33

Zhuang-Fang Yi, Charles H. Cannon, Jin Chen, Cheng-Xi Ye, Ruth D. Swetnam, Developing indicators of economic value and biodiversity loss for rubber plantations in Xishuangbanna, southwest China: A case study from Menglun township, Ecological Indicators, 36 (2014) 788-797

Thomas Guillaume, Anna Mareike Holtkamp, Muhammad Damris, Bernhard Brümmer, Yakov Kuzyakov, Soil degradation in oil palm and rubber plantations under land resource scarcity, Agriculture, Ecosystems & Environment, 23216 (2016) 110-118

Yuwu Li, Xiaobao Deng, Min Cao, Yanbao Lei, Yujie Xia, Soil restoration potential with corridor replanting engineering in the monoculture rubber plantations of Southwest China, Ecological Engineering, 51 (2013) 169-177

Julie-Anne A. Tangena, Phoutmany Thammavong, Anne L. Wilson, Paul T. Brey, Steve W. Lindsay, Risk and Control of Mosquito-Borne Diseases in Southeast Asian Rubber Plantations, Trends in Parasitology, 32 (2016) 402-415

Wenjie Liu, Qinpu Luo, Hongjian Lu, Junen Wu, Wenping Duan, The effect of litter layer on controlling surface runoff and erosion in rubber plantations on tropical mountain slopes, SW China, CATENA, 149 (2017) 167-175

Juan Li, Lijun Zhou, Weifu Lin, Calla lily intercropping in rubber tree plantations changes the nutrient content, microbial abundance, and enzyme activity of both rhizosphere and non-rhizosphere soil and calla lily growth, Industrial Crops and Products, 132 (2019) 344-351

Chang-An Liu, Ming-Yue Liang, Yu Nie, Jian-Wei Tang, Kadambot H. M. Siddique, The conversion of tropical forests to rubber plantations accelerates soil acidification and changes the distribution of soil metal ions in topsoil layers, Science of The Total Environment, 69615 (2019) Article 134082

Decision No. 750/QĐ-TTg of the Prime Minister, dated 03rd June 2009, on approving the Rubber plantation Development Plan by 2015 with a vision to 2020 (Vietnamese)

Decision No. 2456/QĐ-UBND of the People's Committee of Dak Lak Province, dated 20 October 2014, on approval of the development plan of rubber plantation in Dak Lak province in the period of 2014-2020 (Vietnamese).

Department of Agriculture and Rural Development of Dak Lak province (May 2017), Report on implementation of agricultural and forestry development projects in Dak Lak province (Vietnamese).

P. R. van Gardingen, M. J. McLeish, P. D. Phillips, Dadang Fadilah, G. Tyrie, I. Yasman, Financial and ecological analysis of management options for logged-over Dipterocarp forests in Indonesian Borneo, Forest Ecology and Management, 183 (2003) 1-29

Wolfgang Bischoff, David M. Newbery, Marcus Lingenfelder, Rainer Schnaeckel, G. Hubert Petol, Leopold Madani, Colin E. Ridsdale, Secondary succession and dipterocarp recruitment in Bornean rain forest after logging, Forest Ecology and Management, 218 (2005) 174-192

Yves Laumonier, Andreas Edin, Markku Kanninen, Agung W. Munandar, Landscape-scale variation in the structure and biomass of the hill dipterocarp forest of Sumatra: Implications for carbon stock assessments, Forest Ecology and Management, 259 (2010) 505-513

Ha T. T. Do, John C. Grant, Ngoc Bon Trinh, Heidi C. Zimmer, Lam Dong Tran, J. Doland Nichols, Recovery of tropical moist deciduous dipterocarp forest in Southern Vietnam, Forest Ecology and Management, 43315 (2019) 184-204

Elias Ganivet, Joanes Unggang, Vilma Bodos, Malcom Demies, Chea Yiing Ling, Julia Sang, Mark Bloomberg, Assessing tree species diversity and structure of mixed dipterocarp forest remnants in a fragmented landscape of north-western Borneo, Sarawak, Malaysia, Ecological Indicators, 112 (2020) Article 106117

Phung Chi Sy (2018). Report on scientific research results of Dak Lak province "Research on the application of environmental economic instruments to assess the impacts of establishing rubber plantation on dipterocarp forest lands in Dak Lak province" (Vietnamese).