Available online at www.sciencedirect.com
ScienceDirect
Agriculture, Ecosystems and Environment xxx (2008) xxx–xxx
Agriculture Ecosystems & Environment
www.elsevier.com/locate/agee

District-scale prioritization for A/R CDM project activities in Indonesia in line with sustainable development objectives

Daniel Murdiyarso [a,*], Meine van Noordwijk [b], Atie Puntodewo [a], Atiek Widayati [b], Betha Lusiana [b]

[a] Center for International Forestry Research, Jl. CIFOR, Situgede, Bogor Barat 16115, Indonesia
[b] World Agroforestry Centre (ICRAF), Southeast Asia Program, Jl. CIFOR, Situgede, Bogor Barat 16115, Indonesia

Abstract

The promise of the Clean Development Mechanism (CDM) to deliver its dual objectives is currently under public scrutiny. In land-use, land-use change and forestry (LULUCF) activities through afforestation and reforestation projects, known as A/R CDM, the deliverables that demonstrate sustainable development remain unclear. While the methods to convincingly demonstrate carbon benefits are fine-tuned, there is growing concern on a lack of socio-economic benefits of the projects. With the criteria for sustainable development left with the national approval process, CDM projects in a medium-income country with transparent criteria may be more supportive to the socio-economic targets of CDM than in a low-income country without further specifications. At national scale, priority areas can be identified on the basis of publicly available data on land cover and the human development index (HDI). In a case study for Indonesia we found that population density between a lower and upper limit, and risks of fire incidence are socio-economic indicators which could further guide choices within the domain of technically eligible lands (without forest cover in 1990). Within the 302 districts across Indonesia covering a land area of around 193 million ha, the eligibility criteria based on the Marrakesh Accord (later called ‘‘hard’’ criteria) identified 47 million ha of land. With additional (later called ‘‘soft’’) criteria of a population density between 10 and 100 persons km^{-2} and a below-average HDI, 17.3 million ha of eligible lands distributed over 53 districts were prioritized. Differences in fire risk lead to a further stratification of clusters of similarity within this priority domain, with CDM possible at high as well as low fire risk, but requiring different types of project. By grouping districts in clusters of overall similarity of land cover, three main clusters with 7.9, 0.7 and 3.7 Mha of prioritized eligible lands were identified where pilot activities for CDM may be implemented with higher probability of development benefits and extrapolation potential.

Keywords: Kyoto land eligibility; Cluster analysis; Priority district; Fire risks

1. Introduction

In the context of the United Nations Framework Convention on Climate Change (UNFCCC), over a dozen of pilot carbon forestry projects were initiated in the late 1990s under the Activities Implemented Jointly (AIJ) pilot phase in countries such as Belize, Brazil, Bolivia, Chile, Costa Rica, Mexico, Indonesia, and Vietnam. Some of these activities were turned into project activities under the Kyoto Protocol’s Clean Development Mechanism (CDM). Project type and size were very much depending on the stakeholder interests. It was argued that large-scale industrial plantations and strict forest protection are economically viable, but pose the highest social risks. Ambitious claims have been made about the development benefits of market-based policy instruments (Brown and Corbera, 2003). However, socially beneficial projects are less cost-effective because of their higher transaction costs (Smith and Scherr, 2003). Under the National Strategy Study Indonesia identified eight CDM-forestry projects with carbon benefit ranging between 34 and 801 kt CO_2/y (Murdiyarso, 2006). It turned out that these projects were not channeled through the Executive Board (EB) of the

* Corresponding author.
E-mail address: d.murdiyarso@cgiar.org (D. Murdiyarso).

0167-8809/$ – see front matter © 2008 Elsevier B.V. All rights reserved.
doi:10.1016/j.agee.2008.01.008

CDM due to various reasons related to the institutional arrangement and legal documents of the project sites. Development of the Project Design Document (PDD) is an important step in the process by which the Designated Operational Entity (DOE) – an independent body – could verify that the projects meet the requirement of the EB for the subsequent issuance of Certified Emission Reductions (CERs) if the project succeeds.

In this project cycle it is necessary that the selected sites for the CDM-forestry projects are supported by information regarding the history of the lands so that afforestation (A) or reforestation (R) activities may be implemented following the Marrakesh Accord (Decision 17/CP.7). In addition to the definitions of afforestation and reforestation provided by the Decisions, the definition of forest was left to the national authorities. A number of considerations apply to the choice of crown cover and tree height in these definitions (Verchot et al., 2007), as they affect both the eligibility of lands (below the threshold in 1990) and the minimum criteria for success (reaching above the threshold).

Indonesia has chosen a definition of forest that is based on at least 30% crown cover by trees, with trees defined as woody perennials that can reach at least 5 m high. In contrast to the definition suggested by FAO for forestry applications (FAO, 1999), the Indonesian definition could potentially include plantations of rubber, oil-palm and timber, as well as most agroforestry systems where timber or fruit trees (with at least 30% crown cover) are grown in combination with annual food crops or grasses as fodder.

With its land area of more than 190 Mha Indonesia is administratively divided into 33 provinces which comprise of 302 districts. The district scale is particularly important as authorities at this level have the responsibility to host A/R CDM projects in coordination with the Designated National Authority (DNA). Once the lands within each district are classified as 'eligible' on the basis of historical forest cover, the next steps in the CDM process require estimates of actual carbon stocks and potential carbon sequestration rates for various reforestation options. Estimates are needed for both baseline and project scenarios in order to assess additionality and hence, carbon benefits (van Noordwijk et al., this issue).

Following the Marrakesh Accord, we established and used spatially explicit ''hard'' criteria regarding the definition of afforestation and reforestation to select potentially eligible lands. In order to reflect the concerns of the host countries regarding sustainable development objectives, we proposed and exercised ''soft'' criteria by considering population density, human development index and fire risks to further screen the eligible areas to be prioritized. It is recommended that to develop the PDD, one could start with priority areas or districts. More detailed concerns may be explored through Focus Group Discussion (FGD) in respective areas or districts.

2. Materials and methods

2.1. Land eligibility based on 1990 forest cover

Back-dated quality-controlled spatial datasets on land cover are used to determine eligible lands to carry out CDM project activities under the Kyoto Protocol. These are, firstly, the map produced by the World Conservation Monitoring Centre (WCMC, 1996) representing land cover in Indonesia before 1990 using very broad vegetation type categories. The map was based on Landsat and SPOT imageries provided by RePPProT (1990). The second dataset represents the land cover after 1990 produced by the Tropical Ecosystem Environment observation by Satellite (TREES) project of the EU-Joint Research Center (Stibig et al., 2002). The map was based on the SPOT4 Vegetation satellite imageries with a spatial resolution of 1 km.

After corrections and adjustment of the scales and land-cover categories, overlaying the pre-1990 map of WCMC on the post-1990 map of TREES could indicate the area where CDM project could be carried out. These are areas where non-forest lands remain unchanged after 1990. All areas classified as 'conservation' forest on maps of the Ministry of Forestry (1999) were deemed ineligible, even if they did not have actual forest cover in 1990. However, areas of 'protection forest' or 'production forest' designation but without actual tree cover in 1990 were considered to be potentially eligible. Protection forest ('Hutan lindung') land-use class refers to steep slopes protecting watersheds where no form of logging is allowed. Where these lands did not have actual forest cover in 1990, they are eligible for reforestation with non-timber trees. Non-forested 'production forest' land would not be eligible if the FAO definition of 'forest' were used (where the intention of growing trees is enough to qualify as forest land), but it is eligible under Indonesia's definition that is based on actual land cover. Conflicting interpretations of this rule, however are reported by van Noordwijk et al. (this issue).

Further filters were applied to exclude inland water bodies and rice fields as unlikely candidates for reforestation where projects cannot be implemented.

2.2. Population density

District level population data collected by the National Statistical Agency (BPS) were combined with area data to calculate human population density. A tentative classification of districts was made according to the following categories:

Low: <10 persons/km^2.
Lower medium: 10–100 persons/km^2.
Upper medium: 101–300 persons/km^2.
High: >300 persons/km^2.

2.3. Human development index

The human development index (HDI) is an internationally standardized indicator of human welfare that provides information beyond average per capita income or the fraction of the population below a preset 'poverty line'. The HDI is based on three components: life expectancy at birth (X_1), as indicator of health specifically sensitive to the infant mortality rate; educational attainment (X_2), as measured by the combination of adult literacy rate and mean years of schooling; and standard of living (X_3), as measured by adjusted per capita expenditure. Based on data of the National Bureau of Statistics (BPS, 2000), educational attainment (X_2) was measured by using two indicators literacy rate and mean years of schooling. The literacy rate is defined as the proportion of population aged 15 years or older who are able to read and write, in Latin, Arabic or other scripts, as a percentage of this age group. Mean years of schooling are defined as the average years of formal schooling attended among the population aged 15 years or older. As a proxy of the standard of living the adjusted real per capita expenditure is used after taking into account the Consumer Price Index (CPI) and the Purchasing Power Parity (PPP) for each region as the relative price of a certain bundle of commodities. The HDI was calculated for each district as the simple average of the indices of the three components:

$$\mathrm{HDI} = \frac{(\mathrm{Index}\,X_1 + \mathrm{Index}\,X_2 + \mathrm{Index}\,X_3)}{3} \qquad (1)$$

Based on BAPPENAS and UNDP (2004) the HDI was grouped into four categories:

Very poor: <50.
Poor: 50–65.
Medium: 65–80.
Not poor: >80.

2.4. Fire risk

Fire risk to reforestation efforts is likely associated with the existing fire frequency in the area, as evident from the frequency of 'hot spots' in years in between two *El Nino* events (Murdiyarso et al., 2002a,b). For the current analysis the hot spot frequency as observed by the NOAA-AVHRR satellite at a scale of 1 km^2 pixels was calculated for the period between the El Niňo years of 1998 and 2004. The frequency was grouped into three categories:

Low: <1 day with reported hot spot at pixel scale per year of observation.
Medium: 1–2.
High: 2–3.

As district-scale indicator we calculated:

LFraction = affected area classified as low hot spot frequency per district area.
MFraction = affected area classified as medium hot spot frequency per district area.
HFraction = affected area classified as high hot spot frequency per district area.

A fire risk index (FRI) was then defined as the sum of fractions of areas affected by each fire frequency category multiplied by weighting factors for each category. The factors were arbitrarily chosen as 1, 3 and 10 for the low, medium and high frequencies, respectively. Hence:

$$\mathrm{FRI} = (1 \times \mathrm{LFraction}) + (3 \times \mathrm{MFraction}) + (10 \times \mathrm{HFraction}) \qquad (2)$$

Finally, based on the FRI, the districts were classified according to overall fire risk as:

Low: FRI < 0.05.
Medium: 0.05 < FRI < 0.20.
High: FRI > 0.20.

2.5. Combining soft and hard selection criteria

A spreadsheet, available from the authors, was constructed to generate a list of prioritized districts for user-selected settings of the various criteria.

For the results presented here the following settings were used for the "soft" criteria:

- Districts with an HDI below the national average of 64.9.
- Districts with a 'lower medium' population density of between 10 and 100 persons/km^2; at very low densities 'reforestation' is likely to depend on external supply of labor, while at high densities tree-based land-use systems are unlikely to provide sufficient returns to labor, leading to competition for land between tree-based and intensive land-use types.
- Districts with at least 15% of the area that is eligible and non-rice field lands, as below this value CDM is unlikely to warrant attention at district scale.

2.6. Cluster analysis for domains of similarity

To assist in the identification of 'pilot' districts with a clear extrapolation domain in Indonesia, a cluster analysis was conducted. Overall, 283 districts (Kabupaten) were used for the analysis, excluding districts with 'missing data'. The districts were grouped using cluster analysis based on the following variables: forest fraction (fraction of district area), paddy field fraction (fraction of district area), population density (person km^{-2}), life expectancy at birth (years), adult literacy rate (percentage), mean years of schooling (years), adjusted per capita expenditure ($) and fire risk index (scaled 0–1).

3. Results

The ‘‘hard’’ criteria was able to select 47 Mha eligible land in 302 districts out of 193 Mha of land area of Indonesia. Further screening using one of the ‘‘soft’’ criteria—HDI brought the figure down to 17.3 Mha found in 53 districts. When a low FRI was used as additional criterion only 13 districts may be prioritized involving an area of 12.3 Mha.

3.1. Forest cover in relation to population density

Forest cover in 1990 across Indonesia was correlated to district-scale population density (Fig. 1A). While the relationship within each island group is relatively weak, across Indonesia around 63% of the variation in forest cover is associated with population density:

$$\text{Forest\_Fraction} = -0.1319\ln(\text{Population\_Density}) + 1.1137 (R_2 = 0.63) \quad (3)$$

The equation assumes population density to be more than 2.4 km^{-2}. The equation can be used to derive a ‘baseline’ expectation of forest cover in a district on the basis of its population density, and determine the positive or negative difference with this expected value.

As expected, the paddy rice fraction in districts is positively related to population density (Fig. 1B). The area non-forested in 1990 and non-paddy rice field (CDM eligible lands) is positively related to population density across Indonesia (Fig. 1C).

In Fig. 1C a ‘window’ of population densities between 10 and 100 km^{-2} is indicated as ‘soft’ criterion for prioritized districts. Murdiyarso et al. (2002a,b) indicated that the population density where the majority of people is employed in a rubber agroforestry landscape is about 70 km^{-2}. Rubber agroforestry is among the most labor intensive forms of agroforestry, remunerative above minimum wage level. We thus expect that at population densities above 100 km^{-2} non-tree bases land uses are needed to provide agricultural employment. The lower limit of 10 km^{-2} was identified on the basis of the labor requirement for intensive rotation woodlots. Landscapes with lower population density may have to rely on immigration of labor, which likely defies the local development goal.

3.2. Human development index

The first selection through the eligibility criteria throughout Indonesia is summarized in Table 1. The table

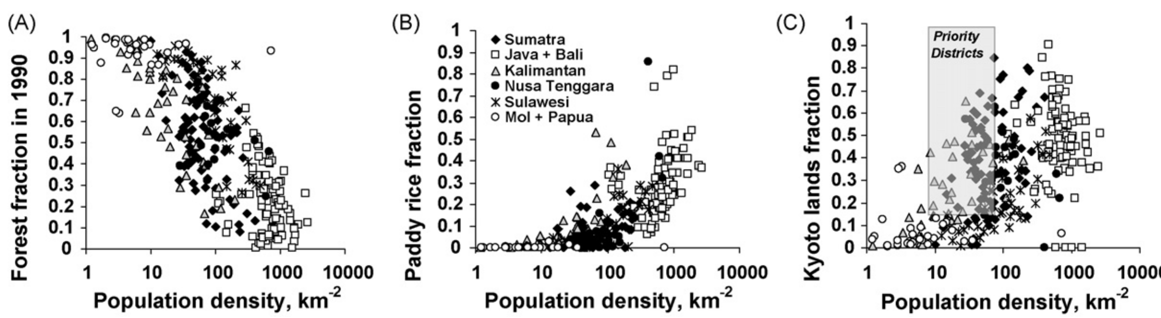

Fig. 1. Relationship between district-level population density (logarithmic scale; classified by island group) and (A) the 1990 forest fraction, (B) the rice paddy fraction and (C) the fraction of CDM eligible lands; the districts with intermediate population density and at least 15% of eligible lands are indicated for prioritization.

Table 1
Total area of eligible lands per island group of Indonesia, and the number of districts and their area of eligible land prioritized on the basis of population densities between 10 and 100 km^{-2}, at least 15% of eligible lands, and an HDI of below 64.9 (as the population-weighted average for Indonesia)

	Number of districts	Eligible land (ha)	Forest fraction 1990	Paddy rice fraction	Potential CDM fraction	Population density (km^{-2})	HDI	FRI
Island groups								
Sumatra	82	19,939,403	0.546	0.072	0.382	84	66.0	0.119
Java + Bali	90	6,036,837	0.216	0.339	0.445	787	64.9	0.092
Nusa Tenggara	20	2,403,125	0.527	0.121	0.352	159	55.6	0.005
Kalimantan	39	11,565,185	0.649	0.090	0.260	32	66.1	0.170
Sulawesi	41	2,541,894	0.691	0.104	0.205	130	59.9	0.032
Maluku + Papua	30	4,820,257	0.930	0.002	0.069	31	61.4	0.000
Overall								
Indonesia	302	47,306,701	0.517	0.155	0.328	293	60.7	0.086
Prioritized								
Indonesia	53	17,314,199	0.519	0.062	0.419	43	60.1	0.138

Please cite this article in press as: Murdiyarso, D., et al., District-scale prioritization for A/R CDM project activities in Indonesia in line with sustainable development objectives, Agric Ecosyst Environ (2008), doi:10.1016/j.agee.2008.01.008

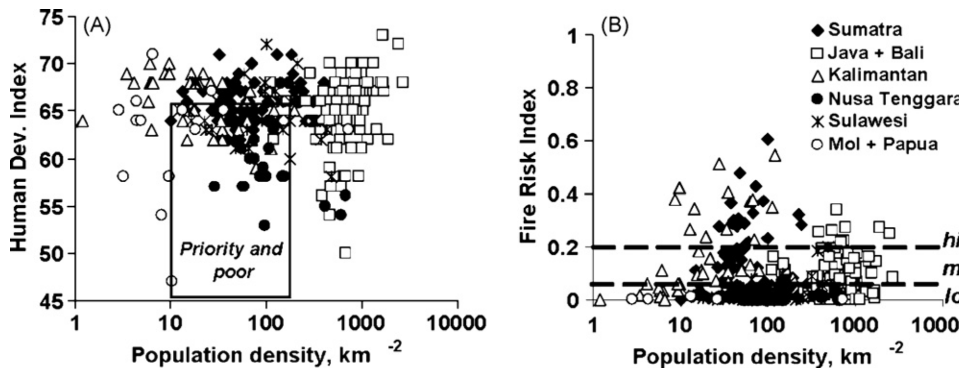

Fig. 2. (A) Human development index (HDI) and (B) fire risk index in relation to district level population density in Indonesia, classified by island groups.

also shows the summary of the prioritized districts and the area involved when HDI and FRI criteria were involved.

Across Indonesia there is no obvious relationship between HDI and population density (Fig. 2A). Below-average values of district level HDI occur in each of the island groups, but especially in the Nusa Tenggara islands of eastern Indonesia and parts of Java + Bali. At district scale none of the districts reaches the 'not poor' value of 75. By combining the relationships between forest cover, population density and HDI we obtain a broad scatter of points. For Java + Bali (plus the southern part of Sumatra) relatively high forest cover is associated with relatively low HDI; for the other islands HDI and forest cover appear to be positively related (data not shown).

As indicated by the window in Fig. 2A, selection of below-average HDI and population density between 10 and 100 km^{-2} still yields a considerable number of candidate districts. In total 53 (17% of the total) districts with a total area of 17.6 Mha meet the criteria set. Compared to the average for all districts in Indonesia, this prioritized group has about the same forest fraction (50%), less rice paddy fields, a slightly lower HDI and a higher frequency of fire.

3.3. Fire frequency and clusters of similar districts

Fire frequency is not a direct reason to decide in favor or against a district: in areas of high fire frequency measures that reduce fire will be expected to have a positive effect on carbon stocks, and this may represent 'easy wins'; on the other hand, areas with low fire frequency may reflect situations where reforestation is relatively easy too. The nature of CDM projects, between these cases will have to adjust to the local situation (van Noordwijk et al., 2005).

The distribution of the fire risk index in Indonesia shows some clear patterns (Fig. 3A): high risk areas occur mainly in the lowland peneplain and coastal zone of the southern half of Sumatra and West Kalimantan. Part of South Kalimantan are also in this class, while the districts identified along the north coast of Java probably reflect the burning of rice straw in areas of low reforestation potential.

A hierarchical cluster analysis of all districts across Indonesia yielded 15 groups of districts at 96% similarity. Table 2 describes the 6 clusters among this group that contain at least 6 districts.

The three largest clusters (A, B, and C in Table 2) contain 255 out of 302 (84%) of all districts, and 89% of prioritized districts. These clusters are distributed as follows:

- Cluster A: 95% of Nusa Tenggara, 70% of Sumatra, 68% of Sulawesi, 51% of Kalimantan, 40% of Maluku + Papua and only 14% of districts on Java + Bali. Forest cover on average 7% above what would be expected for the local population density. Low to medium fire risk and relatively

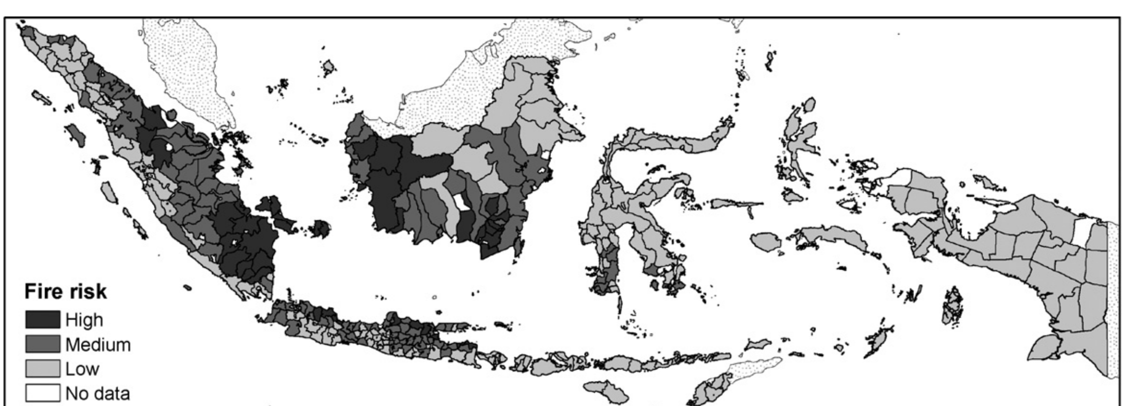

Fig. 3. Spatial distribution of fire risk index (FRI) in Indonesia at district scale.

Table 2
Description of cluster characteristics, based on district level data on land cover, population density and components of the human development index; 'special case' clusters with less than 5 districts were excluded; the number of districts prioritized per cluster is based on the 'default' criteria; forest cover is reported as difference with the 'baseline' value expected on the basis of population density and the regression equation for Indonesia as a whole

	HDI	Pop. density (km^{-2})	FRI	Forest fraction 1990	Paddy rice fraction	Number of districts								Prioritized	
						Total	Sumatra	Java + Bali	Nusa Tenggara	Kali-mantan	Sula-wesi	Maluku + Papua	CDM eligible land (ha)	No. of districts	CDM eligible land (ha)
Indonesia	64.6	293	0.086	0.000	0.099	302	82	90	20	39	41	30	47,306,701	53	17,314,199
Cluster															
A	64.8	156	0.044	0.074	0.106	150	58	13	19	20	28	12	19,183,752	34	7,897,289
B	65.0	615	0.100	-0.043	0.057	82	11	63	0	0	8	0	7,561,943	4	699,313
C	65.0	105	0.321	-0.223	0.245	23	11	0	0	10	2	0	7,129,702	9	3,739,645
D	61.2	16	0.001	0.013	0.013	19	0	0	1	0	3	15	2,223,862	2	170,904
E	65.9	836	0.078	-0.066	0.060	9	0	9	0	0	0	0	618,028	0	0
F	66.3	7	0.043	-0.097	0.158	6	0	0	0	6	0	0	3,032,430	0	0
Clusters of <5	61.8	331	0.214	-0.119	0.124	13	2	5	0	3	0	3	7,556,983	4	4,807,049

high area of paddy rice fields per capita. Average level of HDI and mean population density 156 km^{-2}; 64% of the prioritized districts fall into this cluster. Their combined area of CDM eligible lands is 7.9 Mha.

- Cluster B: 70% of Java + Bali, 20% of Sulawesi, 13% of Sumatra and 7% of Maluku + Papua; high population density (615 km^{-2}), medium fire risk, forest cover 4% below baseline; low per capita area of rice fields; only 7% of the prioritized districts are in this cluster, with a combined area of CDM eligible lands of 0.7 Mha.
- Cluster C: 26% of Kalimantan, 13% of Sumatra and 5% of Sulawesi; mean population density 105 km^{-2}; high fire risk index, 22% less forest cover than expected for the population density; high per capita area of rice fields; 17% of prioritized districts, with a combined area of CDM eligible lands of 3.7 Mha.

Six of the 53 prioritized districts are outside these three big clusters; these (cluster F) may represent 'special cases' that are of less immediate relevance for learning on how to implement CDM in Indonesia, but may be of interest in a second round of learning. Fig. 4 shows the distribution of the prioritized districts according to the three main clusters.

4. Discussion

In current discussions on climate change impacts and the requirements of adaptation, the opportunities for combining adaptation and mitigation receive renewed attention (Verchot et al., 2007). Where human vulnerability is a major policy concern, the selection of areas where enhancement of trees in the landscape could provide real economic benefits is important. Such a choice relates both to the selection of areas and the selection of activities within these prioritized districts (van Noordwijk et al., this issue).

Spatial data that are available through public sources for Indonesia are sufficient for a systematic approach to the prioritization of districts for A/R CDM applications that are compliant with the rules of the Kyoto Protocol and that target areas where tree-based land-cover change is most likely to support development. Excluding areas of low

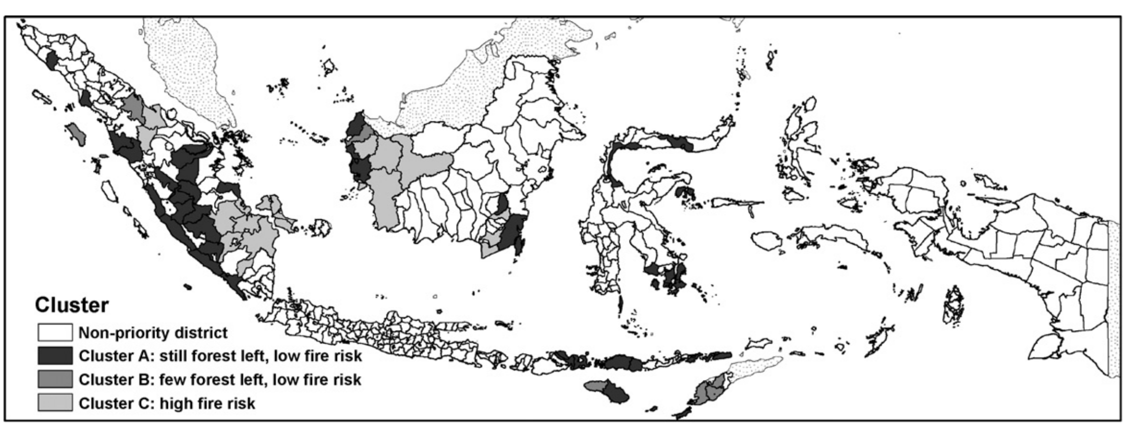

Fig. 4. Domains of similarity of 53 prioritized districts harboring 17.3 million ha of CDM eligible lands (clusters A, B, and C of Table 2), 12.3 million ha of which are exposed to low fire risk and distributed in 13 districts.

Please cite this article in press as: Murdiyarso, D., et al., District-scale prioritization for A/R CDM project activities in Indonesia in line with sustainable development objectives, Agric Ecosyst Environ (2008), doi:10.1016/j.agee.2008.01.008

population densities did not prove to be a strong selection criterion, but the upper limit we selected is in the middle of the distribution, and a small shift includes or excludes a substantial number of districts. Areas within the districts that just exceed the threshold may in fact still be of interest for A/R CDM.

The 'cluster analysis' lead to recognition of three main domains for testing A/R CDM in Indonesia, differing in overall land use in relation to population density. The specific forms of A/R CDM will have to differ between these clusters.

Subsequent discussions with stakeholders from prioritized and non-prioritized districts, officials from the Ministry of Forestry and the Ministry of Environment have added further selection criteria that lead to a final 4 districts that were selected for development of PDDs for approval by the DNA during 2006. Four PDDs were developed through a long process of consultations at both local and central levels. As discussed by van Noordwijk et al. (this issue), however, 'forest lands without trees' where effectively included in the forest definition, which reduced the eligibility below what is presented here. The 'poverty' and 'development' criteria played a relatively minor role in the subsequent discussions at government level. The perceived level of 'administrative preparedness' was an important additional criterion, and in view of the administrative processes of proposal development and agreements required at various levels of the government system, 'connectedness' proved to be more important than the 'hard' or 'soft' criteria we used in the analysis we presented here. Rules for future timber harvests did play a major role in the subsequent discussions and lead effectively to the exclusion of 'protection forest' areas where such timber harvests would not be allowed, even though the option of future timber harvests is not an international prerequisite for A/R CDM. At some stage the possibility of combining the government-sponsored reforestation program to attract additional external funding through CDM investments was also discussed. This could potentially create a challenge on additionality criterion.

It was clear that the government is keen to play a more significant role by acting as regulator and intermediary between sellers and buyers under an A/R CDM scheme. A similar situation was found elsewhere, in contrast with the AIJ Pilot phase where investors from developed countries and local sellers in developing countries were mediated by non-government organizations (Pagiola et al., 2002). It remains to be formally evaluated if the current institutional arrangement would significantly increase transaction costs. Final appraisal can only be made when the first batch of the PDD reaches the endpoint of the approval process. High transaction cost should be avoided if sustainable development objectives are to be met.

Overall, the forest policy related issues beyond the direct reach of the Marrakesh Accord and international rules for A/R CDM had a major influence on the types of pilot projects that reached the DNA for approval, as various agencies need to approve the proposals before they reach the DNA. If the relevant authorities would want to consider the probability of development benefits and/or the extrapolation potential of pilot sites, the analysis provided here may still be used. With the current focus on pilot areas for 'avoided deforestation' (or reducing emissions form deforestation and degradation), a similar approach to the establishment of domains of similarity between districts may contribute to the decisions that are to be made.

Acknowledgements

The authors wish to thank the Asian Development Bank (ADB) for the support in conducting the study under the Technical Assistance (TA 4137-INO) on Carbon Sequestration through the Clean Development Mechanism, contract No. COCS/04-903. Participants in the workshops organized for capacity building purposes by the Ministry of Environment, the Republic of Indonesia made valuable comments to refine the current analysis.

References

BAPPENAS and UNDP, 2004. National Human Development Report 2004. The Economics of Democracy: Financing Human Development in Indonesia. Jakarta, Indonesia: UNDP. 207 p.

Badan Pusat Statistik (BPS), 2000. Survei Sosial Ekonomi Nasional (SUSENAS). BPS, Jakarta.

Brown, K, Corbera, E, 2003. Exploring equity and sustainable development in the new carbon economy. Climate Policy. Special Supplement on Climate Change and Sustainable Development 3, S41–S56.

FAO, 1999. State of the World's Forests. Food and Agriculture Organization of the United Nations, Rome, Italy, 154 pp.

Ministry of Forestry, 1999. Forestry Statistics of Indonesia 1997/1998. Agency for Forest Inventory and Land Use Planning, Jakarta.

Murdiyarso, D., van Noordwijk, M., Wasrin, U.R., Tomich, T.P., Gillison, A.N., 2002a. Environmental benefits and sustainable land-use options in the Jambi transect, Sumatra, Indonesia. J. Veg. Sci. 13, 429–438.

Murdiyarso, D., Widodo, M., Suyamto, D., 2002b. Fire risks in forest carbon project in Indonesia. J. Sci. China 45, 65–74.

Murdiyarso, D., 2006. Prospects of CDM forestry projects in Indonesia. In: Youn, Y.-C. (Ed.), Climate Change, Kyoto Protocol, and Forest Sector. Korean Studies Information Co. Ltd., pp. 325–341.

Pagiola, S., Bishop, J., Landell-Mill, N., 2002. Selling Forest Environmental Sevices. Earthscan, London.

Regional Physical Planning Programme for Transmigration (RePPProT), 1990. The Land Resources of Indonesia: A National Overview. Land Resources Department, Natural Resources Institute, London, 282 pp.

Smith, J., Scherr, S., 2003. Capturing the value of forest carbon for local livelihoods. World Dev. 31 (12), 2143–2160.

Stibig, H.-J., Beuchle, R., Janvier, P., 2002. Forest Cover Map of Insular Southeast Asia at 1:5500000. TREES Publications Series D: No. 3, EUR 20129 EN, European Commission, Luxemburg.

van Noordwijk, M., Widayati, A., Lusiana, B., Hairiah, K., Arifin, B., 2005. What Can a Clean Development Mechanism Do to Enhance Trees in the Landscape? Experience with Rubber, Coffee and Timber-based Agroforestry Systems in Indonesia. In: Murdiyarso, D., Herawati, H. (Eds.), Carbon forestry: who will benefit? Proceedings of Workshop on Carbon Sequestration and Sustainable Livelihoods. Bogor, Indonesia, CIFOR.

215 p. ISBN: 979-3361-73-5. pp. 92–111. http://www.cifor.cgiar.org/publications/ pdf files/Books/BMurdiyarso0501.pdf.

van Noordwijk, M., Suyamto, D.A., Lusiana, B., Ekadinata, A., Hairiah, K. Facilitating agroforestation of landscapes for sustainable benefits: tradeoffs between carbon stocks and local development benefits in Indonesia according to the FALLOW model. Agric. Ecosyst. Environ., doi:10.1016/j.agee.2008.01.016, this issue.

Verchot, L.V., Zomer, R., Van Straaten, O., Muys, B., 2007. Implications of country-level decisions on the specification of crown cover in the definition of forests for land area eligible for afforestation and reforestation activities in the CDM. Climatic Change 81, 415–430.

World Conservation Monitoring Centre (WCMC), 1996. A Global Overview of Forest Conservation. WCMC/CIFOR CD-ROM, Cambridge.