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Highlights

- We focus on Kenya to assess whether REDD projects are spatially pro-poor.
- Subnational vulnerability indices are used to represent relative poverty.
- Most REDD projects are located in low-vulnerability areas.
- Profit seeking project developers aim to maximise profits in low-vulnerability areas.
- Policy reforms needed to ensure subnational equity in access to REDD funds.

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Are REDD projects pro-poor in their spatial targeting? Evidence from Kenya

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ABSTRACT

Reducing emissions from deforestation and forest degradation (REDD) is globally supported as a cost effective programme that could achieve global mitigation and spur pro-poor socioeconomic development. Various actors are now actively lobbying and disbursing REDD demonstration funds on the premise of spurring pro-poor carbon investments in less developed areas that were otherwise excluded from the Clean Development Mechanism. In practice, little is known as to whether the REDD projects are actually pro-poor in their spatial targeting. This paper focuses on Kenya to analyse the distribution of REDD projects across quantified subnational vulnerability indices. A vulnerability index map for Kenya was first developed from long-term socioeconomic (crop yields, literacy rates and poverty rates) and climate (rainfall) data drawn from the 47 counties of Kenya. The number and types of REDD projects were located on the vulnerability map. Correlation tests were performed and experts consulted to clarify the socioeconomic features of vulnerability that significantly influence spatial choices for the projects. Results show that most projects are located in low-vulnerability counties and are mainly developed and managed by international private and consulting companies. Correlation tests revealed that the low-vulnerability counties, hosting more projects, are endowed with humid forest resources at .728; $p < 0.01$, land title deeds at .552; $p < 0.01$ and better access to water at .475; $p < 0.01$. Experts suggested that such conditions posit low transaction costs and higher carbon revenues for profit-seeking project developers that currently dominate the REDD demonstrations. Conversely, some project experiences indicate that medium to high-vulnerability areas, with mitigation potential, provide low opportunity costs for projects. By directing REDD funds to relatively vulnerable areas, projects and national REDD policies are likely to enhance synergies between mitigation and adaptation. More targeted field-based studies on the practical interaction between projects and local socioeconomic conditions can be formulated from this study.

Introduction

Reducing emissions from deforestation and forest degradation (REDD) is a globally emerging forest programme aimed at mitigating climate change and promoting development in developing countries (Mbow et al., 2012). REDD has attracted international legitimacy as a pro-poor climate policy that links carbon management to human development (Bond et al., 2009). Achieving mitigation and sustainable socioeconomic development, makes REDD a cost-effective mitigation option for developing countries (Stern, 2006).

A diversity of REDD demonstration projects exists in various developing settings (Angelsen et al., 2009). The projects occur in different landscapes ranging from plantations, forest and even agricultural lands (Leach & Scoones, 2013). In this paper, we broaden the scope of REDD demonstrations projects to include both forestry and agroforestry projects that are selling or are designed to sell carbon credits and could potentially generate lessons for a formal national REDD programme. Agroforestry practices are reportedly inherent within most REDD projects both as part of additional carbon sink and alternative source of community livelihoods (Peters-Stanley, Gonzalez, & Yin, 2013).

Negotiations at the United Nations Framework Convention on Climate Change (UNFCCC), have broadly institutionalised safeguards as part of pro-poor benchmark (UNFCCC, 2010; decision 1/CP.16). Safeguards require REDD projects to consult the local people

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in their activities, promote adaptation, reduce poverty while responding to climate change. Based on the safeguards, the 17th Conference of Parties (COP) to the UNFCCC (UNFCCC, 2012; decision 2/CP17) emphasised that Parties and concerned organisations should promote equitable distribution of sustainable development resulting from REDD and other climate funds. A range of multilateral, public and private sector funds have since emerged to demonstrate how REDD could achieve mitigation and development. Examples of such funds include the UN-REDD (UN-REDD, 2008), the World Bank's Bio-Carbon Funds (World Bank, 2011) and the Forest Carbon Partnership Facility (FCPF, F. I. P., & UN-REDD, 2010) and a host of private and public subnational projects. The UN-REDD (2010) predicted a flow of US$30 billion a year due to REDD+ and indicates that this could achieve development goals for poor communities: '[…] this significant North-South flow of funds could reward a meaningful reduction of carbon emissions and could also support new, pro-poor development, help conserve biodiversity and secure vital ecosystem services' (UN-REDD, 2010: 2). As part of these funds, about US$51.4 has been approved to support REDD institutional support to nine developing countries (UN-REDD, 2014).

Demonstration projects are already in place and are distributed across developing countries. This distribution is documented in research articles and reports (Cerbu, Swallow, & Thompson, 2011; Diaz, Hamilton, & Johnson, 2011; Peters-Stanley et al., 2013) and updated within global databases such as the CIFOR's global database for REDD+. The databases and related literature confirm that simplified and diversified funding opportunities within REDD, potentially enable poor countries to access carbon funds if compared to the CDM (Bond et al., 2009; Diaz et al., 2011). However, at subnational level, little is known about the spatial distribution of existing REDD projects across varying socioeconomic and bio-physical conditions.

In designing projects, pro-poor benefits and emission reduction potential are the key criteria used to geographically and conceptually justify the location of REDD projects (Cerbu et al., 2011). Areas endowed with forest resources are mainly justified for REDD because they potentially enable performance in emissions reduction (Harris, Petrova, Stolle, & Brown, 2008; Lin, Sills, & Cheshire, 2014). However, various forest types including tropical humid forests, tropical dry-land forests, tropical seasonal forests and plantation forests, are recognised under REDD even though they have varying mitigation potentials (Gibbs, Brown, Niles, & Foley, 2007).

On the other hand, project proposals often cite poor socioeconomic developments, poverty and limited economic opportunities to justify why REDD is a better conservation and development alternative for such areas (Cerbu et al., 2011). The decision of project investors to be pro-poor in committing REDD funds is crucial because the relative socioeconomic conditions of various areas or communities, influence projects' opportunity costs, investment security (Lin et al., 2014) and overall success (Blom, Sunderland, & Murdiyarso, 2010; Engel, Wunscher, & Wunder, 2009). Pro-poor targeting for REDD projects, in practice, is justified around social justice in the fight against climate change. In this social justice, the additional socioeconomic development from REDD funds, could reduce poverty and address climatic and non-climatic vulnerabilities of communities living within particular developing countries (Eakin & Luers, 2006; Robinson & Berkes, 2011). Vulnerability here refers to the degree to which a community/system is susceptible to, or unable to cope with, adverse effects of climate change variability (IPCC, 2007). Vulnerability of a community depends on how its key livelihood/economic activity is exposed, sensitive and able to adapt to climate change (IPCC, 2007). In most African countries, where REDD is targeting, communities practice rainfed agriculture for food and income and so are more exposed to climate related rainfall variability (IPCC, 2007). Studies e.g. in Kenya (Eriksen & O'Brien, 2007), Ghana (Antwi-Agyei, Fraser, Dougill, Stringer, & Simelton, 2012), indicate that the relative vulnerability of these communities is determined more by their poverty status than the rainfall variability because this variability generally similar effect across a particular country. However, at a wider regional scale, differentiated nature of hazards may make even wealthy populations relatively vulnerable (IPCC, 2007) but even within these wealthy populations, poorer people are often more vulnerable (Grineski et al., 2012). In other words, vulnerability is a key indicator of poverty at subnational level (Adger, 1998). This also means that vulnerability indices calculated from climate and socioeconomic information, usefully reflect the socioeconomic (Samal, Palni, & Agrawal, 2003) and ecological (Abson, Dougill, & Stringer, 2012) dimensions of poverty especially in the context of climate change.

Socioeconomic and climate data have been used to index relative vulnerability of various communities within developing countries such as Ghana (Antwi-Agyei et al., 2012) and South Africa (Gbetibouo, Ringler, & Hassan, 2010). Applying such vulnerability assessment approaches to other counties and linking the results to mitigation and adaptation policies, could usefully inform policy reforms and interventions towards vulnerable communities (Fraser, Simelton, Termansen, Gosling, & South, 2013). An understanding of how the current REDD investment patterns play out with relative subnational vulnerabilities is necessary to inform specific pro-poor actions within national REDD policies and to highlight potential spaces for synergising mitigation and adaptation and attending to climate justice in line with the UNFCCC (2012) recommendations.

This paper draws evidence from Kenya to show how vulnerability linked to poverty, influences the spatial choices of REDD projects. The aim of the paper is to analyse the factors that might influence the ability of communities to access the expected globally designed REDD investments. The specific objectives are: (1) to develop a subnational vulnerability index map for Kenya; (2) to evaluate and locate REDD projects on the vulnerability map; and (3) to characterise the relationship between vulnerability and the spatial location and design of REDD projects. Kenya alongside other developing countries actively engage in REDD demonstrations (Diaz et al., 2011) and policy processes under the World Bank's FCPF REDD preparatory fund. This case study can therefore inform pro-poor REDD policies and project design in Kenya and other developing countries whose REDD institutional development draws from FCPF terms and conditions. More details on the study area are included in the next section on methodology. Results, discussions and conclusions then follow respectively.

Materials and methods

Study area

Kenya is located to the East of Africa at .4252° S, 36.7517° E. The country is administratively divided into 47 counties making up eight provinces (Government of Kenya, 2010b). The country's population currently stands at 41 million persons, 77% of whom live in rural areas. Forty three percent (43%) of the rural population, as of 2011, live below the poverty line (US$1.25 a day) (Government of Kenya, 2009). Kenya's economy depends more on agriculture and tourism. Agriculture contributes about 25% of Kenya's GDP and also supplies numerous non-marketed goods and services to the country's rural population (Government of Kenya, 2010b). Eighty percent (80%) of the country's land is classified as semi-arid to arid (ASALs) while humid conditions are found in the central and western highlands. Temporal variability in rainfall interferes with

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the cropping calendar and drives vulnerability of most rainfed farmers in Kenya (Government of Kenya, 2012). Kenya's resource base consists of national parks, wildlife and forests. Deforestation is a major concern in Kenya. The country loses 12,000 ha of closed canopy forest annually (FAO, 2010). This deforestation is mainly driven by conversion of forest land to small scale agriculture and illegal logging (Government of Kenya, 2010a). The Kenya national climate change action plan for 2013–2017 (Government of Kenya, 2012) recognises REDD as a mitigation and adaptation option that could additionally counter the deforestation. Kenya is getting ready for REDD through the UNFCCC negotiations and within the World Bank's Forest Carbon Partnership Facility alongside. The country is a leading adopter of REDD demonstrations and delivered 64% of all sub-Sahara Africa's REDD related forestry credits in 2010 (Diaz et al., 2011).

Methodological steps

Developing a vulnerability index map for Kenya

This paper utilised vulnerability indexing to represent relative poverty among communities in the context of climate change. Vulnerability index incorporates both the social and climatic variables thereby accounting for both ecological poverty (Samal et al., 2003) and socioeconomic poverty (Abson et al., 2012). Subnational vulnerability studies across Africa; Kenya (Eriksen & O'Brien, 2007), Ghana (Antwi-Agyei et al., 2012), Malawi (Malcomb, Elizabeth, Weaver, & Krakowka, 2014), Tanzania (Paavola, 2008) show that the relative vulnerability of communities within a country is highly a measure of their relative poverty because communities are often faced with similar hazards. The use of vulnerability as an indicator of relative poverty is a useful strategy towards addressing injustices in climate change (Grineski et al., 2012). The IPCC (2001) conceptualises vulnerability as a function of exposure, sensitivity and adaptive capacity. Based on the IPCC concept, proxy socioeconomic indicators (literacy and poverty), agricultural yield indicator (maize yields) and climate indicators (rainfall/temperature) were used to index vulnerability for each of the 47 counties. This indicator approach usefully covered for limitations in temporal socioeconomic data. The indicator approach is recommended and has been applied for geographical areas with limited detailed data such as sub-Sahara Africa (Antwi-Agyei et al., 2012). The vulnerability components were calculated as follows:

Exposure index: We referred to Füssel and Klein (2006) to define exposure index as the degree to which agricultural productivity is exposed to climatic changes. Exposure indices were first calculated for both rainfall and temperature data. We obtained 41 year (1970–2010) monthly rainfall and temperature data for the 47 counties from the Kenya Meteorological Department in Nairobi (Kenya Meteorological Department, 2012). From the data, a 30-year (1971–2000) average rainfall for maize growing period was assigned as a standard reference against which yearly rainfall variations were compared (see e.g. Simelton, Fraser, Termansen, Forster, & Dougill, 2009). The standard 30-year was calculated for the maize growing period in Kenya occurring between March–November each year and this was inclusive of both short and long rainy seasons. The actual amount of rainfall observed during the growing periods (March–November) for each year was divided by the 30-year standard average to calculate exposure index (see equation (1)). Temperature based exposure index was also calculated using the same procedure (see equation (2)) as illustrated in Hawkins et al. (2013)

$$\text{Exposure index\_prep} = \text{sum for the critical growing period/mean of the standard 30 year rainfall for the critical period} \tag{1}$$

$$\text{Exposure index\_temp} = \text{sum for the critical growing period/mean of the standard 30 year temperature for the critical period} \tag{2}$$

Correlation tests were performed to compare the significance of temperature and rainfall exposure indices to changes in crop yields. The most significant indicator was used in vulnerability indexing.

Sensitivity index: We referred to Eriksen et al. (2005) to define sensitivity as the degree to which agricultural productivity (maize yield) is affected either adversely or beneficially by the rainfall or temperature variability (exposure). Changes in maize yields were used to represent agricultural sensitivity to rainfall perturbations. Maize is the staple food grown in all the 47 counties of Kenya and is also a source income and employment for most Kenyans involved in rainfed farming (Kenya National Bureau of Statistics, 2011). The focus on maize also allowed for the calculation of sensitivity indices for all the 47 counties and this would not be possible with other crops that are only cultivated in specific counties. Yearly maize yield data (in tons/ha) for a period of 36 years (1975–2010) was obtained from the Kenya's State Department of Agriculture, Project Monitoring Unit. An extensive review of yearly agricultural reports for each of the Kenyan counties was undertaken to validate the data and fill in missing yield values. The yields were first detrended to remove any changes attributable to non-climatic factors such as technological development (Lobell, Cahill, & Field, 2007). Detrending was achieved through simple calculation of linear trends in the yields (see e.g. Easterling, Chen, Hays, Brandle, & Zhang, 1996). Linear trends provide better balance between yield prediction and simplicity (Chatfield, 2013). In this detrending, the observed yield was plotted against the respective years in a time series. A linear trend was fitted on the plot, and the equation of this linear trend was used to calculate the expected yields. Resulting differences in the observed and expected yields were interpreted as residuals attributable to technology. The ration of expected to observed yields represented the sensitivity index (see e.g. Simelton et al., 2009; equation (3)).

$$\text{Sensitivity index} = \text{expected yield (tons/ha)} \times /\text{actual yield (tons/ha)} \tag{3}$$

Adaptive capacity index: Adaptive capacity here refers to the ability of a community to moderate the effects of rainfall/temperature perturbations (exposure index) on crop yields (sensitivity index). Adaptive capacity is determined by the five categories of livelihood assets (natural, financial, human, social and physical assets) making up the sustainable livelihood framework (Gbetibouo et al., 2010). Using indicators from all the five livelihood asset categories to index adaptive capacity makes a study more comprehensive (Challinor, Wheeler, Garforth, Craufurd, & Kassam, 2007). However, an appropriate level of indicators usefully reduces complexity and large errors associated with parameterisations (Challinor et al., 2007; Vincent, 2007). Due to lack of long term socioeconomic data for the 47 counties of Kenya, adaptive capacity index was calculated from poverty and literacy rates (see equation (4)). County poverty and literacy data were available for two years; during 2005/2006 Kenya National Household Budget Survey (Kenya National Bureau of Statistics, 2007) and the 2009 national population and household census (Government of Kenya, 2009). The population census is a regular ten-year exercise and often gathers population income and literacy data while household budget surveys assesses all the household assets but mainly when funds are available making it difficult to have consistent temporal socioeconomic data. Additional socioeconomic data were available from the 2005/2006 household budgetary survey but could not be included in the indexing because such point data could compromise the temporal perspective of adaptive capacity. Nonetheless, poverty and literacy rates are recommended as adequate indicators to index adaptive capacity in situations where data is limited (Simelton et al., 2009).

$$\text{Adaptivecapacity index} = (\text{Literacy rate}/100) + (100 - \text{poverty rate})/100 \quad (4)$$

Overall vulnerability for each of the 47 counties of Kenya was calculated using equation (5). Statistical Package for Social Sciences (SPSS) was used to perform hierarchical clustering of the counties into 'low' 'medium' and 'high' vulnerability. Hierarchical clustering allows data to be classified without pre-determining the number of clusters. Discriminate analysis was performed to validate and correct the clusters accordingly. Using ArcGIS, the vulnerability clusters were overlaid on the Kenya-county map to generate a vulnerability map for Kenya.

$$\text{Overall vulnerability} = \text{Exposure index} + \text{Sensitivity index} - \text{AdaptiveCapacity index} \quad (5)$$

Locating REDD projects on the vulnerability map

An inventory of REDD projects occurring in various parts of Kenya was undertaken. Projects operating under various standards including Voluntary Carbon Standard (VCS), Climate Community and Biodiversity Standard (CCBS), Plan vivo, and the Chicago Climate Exchange were considered in the inventory. As clarified in the introduction, both forestry and agro-forestry projects (e.g. climate smart agriculture projects) were included in the inventory with the understanding that all these projects posit lessons for the expected national REDD. Recent inventories of forestry carbon projects (Diaz et al., 2011; Peters-Stanley et al., 2013) show that most REDD projects pursue agroforestry practices as part of alternative livelihood initiative and at the same time apply similar monitoring protocols for both forestry and agroforestry outcomes. Existing and upcoming (pipeline) projects were considered in the inventory and were usefully indicative of the spatial flow of carbon investments currently and in the future. Table 1 shows the types of data gathered about the projects. The projects' locations and types were overlaid on the vulnerability map.

Characterising the REDD – vulnerability linkage

We explored the socioeconomic characteristics that may significantly influence the spatial targeting for the REDD projects. Given the insignificant number of projects in each country, it was not possible to directly compare the county-socioeconomic characteristics with project numbers. Therefore, we assumed a causal relationship in which socioeconomic indicators that showed significance to vulnerability were interpreted as factors influencing the spatial attractiveness or unattractiveness to REDD projects. This causal assumption was however validated through expert consultations. Pearson correlation was performed between sixteen (16) socioeconomic indicators, whose selection was informed by our scoping study (Atela, 2013), found at; http://steps-centre.org/wp-content/uploads/Governing-REDD+.pdf.

Table 1
Project attributes considered in the REDD-project inventory and corresponding data sources.

Project attribute	Data source
a. Project type and existence	❖ Global databases: CIFOR's global REDD map (http://www.forestclimatechange.org/redd-map/) ❖ REDD inventory report: Ecosystem market place state of forestry carbon report 2013. ❖ Field visits to selected project sites in Kenya
b. Project geographical location	❖ Project design document ❖ Google earth application
c. Forest type	❖ Project design documents ❖ Vegetation map of Kenya
d. Project validation standards	❖ Project design document
e. Project design objectives	❖ Project design document
f. Project stakeholders	❖ Project design document ❖ Interview with project staff

Data on the indicators were obtained from the 2005/2006 National Household Budget Survey of (Kenya National Bureau of Statistics, 2007). The indicator values were standardised into percentage (0–100) to achieve normalised weights (see e.g. Gbetibouo et al., 2010). A research visit to the UNFCCC in Bonn Germany allowed for interviews with UNFCCC experts ($n = 4$). Particularly to clarify the observed spatial distribution of REDD projects and the relationship between certain socioeconomic indicators and locating the projects. National REDD staff ($n = 2$) and staff of the Kasigau Corridor REDD project and the Kenya Agricultural Carbon project ($n = 8$) were also consulted to verify how the socioeconomic indicators affect projects work.

Data summary and limitations

The study applies quantitative data to index vulnerability and compare with project numbers. Vulnerability indices were generated from agriculture, climate and socioeconomic data gathered from respective government departments and documents. While long term agricultural and climatic data were available and were verified through documents, limited temporal socioeconomic data restricted the number of socioeconomic indicators included in adaptive capacity indexing for vulnerability. However, correlation tests between adaptive capacity and yield sensitivity usefully validated the appropriateness of the two indicators in representing adaptive capacity. The resulting vulnerability index map should be interpreted in relative rather than absolute terms and has been used here to frame the spatial flow of REDD funds and similar procedures.

Results

Vulnerability index map for Kenya

Counties with vulnerability indices in the range of .050–.113 ($\mu = .766$), were classified as low-vulnerability, while those in the range of .113–2.141 ($\mu = 1.615$) and 2.141–2.782 ($\mu = 2.429$) were classified as medium and high-vulnerability respectively (Fig. 1).

The vulnerability indices were calculated from long-term precipitation (exposure), crop yield (sensitivity) and socioeconomic data (adaptive capacity). Correlation coefficients showed that

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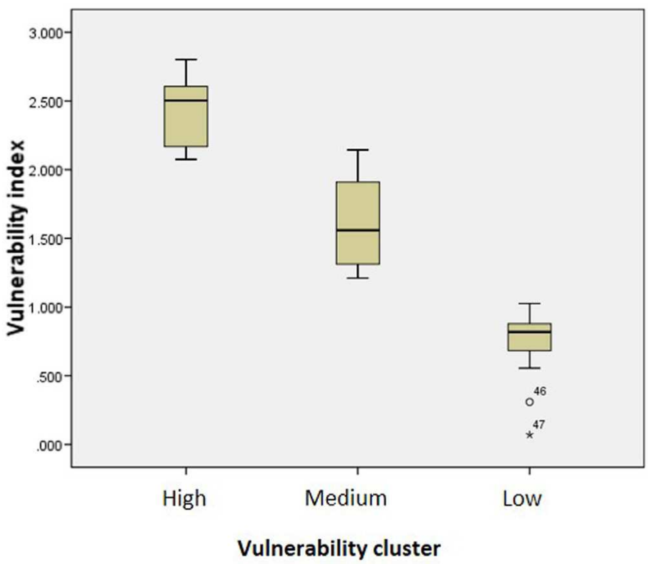

Fig. 1. Vulnerability clusters for the 47 counties of Kenya. Meru (46) and Nairobi (47) counties were outliers.

precipitation changes within the maize growing period accounted for about 54.8% ($p < 0.05$) of changes in maize yields (sensitivity indices), higher than temperature coefficient of 43.2% ($p < 0.05$). The significance of precipitation to yield sensitivity nonetheless varied across the high (69.8%), medium (52.1%) and low (48.4%) vulnerability clusters. The variation in precipitation (exposure index) was not significantly different between the clusters ($p = 0.06$) even though the cluster sensitivities were significantly different ($p < 0.05$). County adaptive capacity indices were highly significant to the changes in maize sensitivity at .768; $p < 0.01$, and to the vulnerability indices at −.887; $p < 0.001$.

The vulnerability indices show that 8 of the 47 counties (17.02%) were clustered as high, 11 counties (23.41%) as medium and 28 counties (59.57%) as low vulnerability (Fig. 2). North Eastern region had the highest proportion (100%) of counties in the high-vulnerability category while Central, Nairobi and Nyanza regions had no county in the high-vulnerability cluster. Two counties (Marsabit and Isiolo) constituting 25% of the counties in the Eastern region were clustered under high-vulnerability while Samburu and Turukana counties constituting 14.3% of the counties in Rift valley were clustered under high-vulnerability. One county in the Coast province (Tana River) was clustered under high-vulnerability.

Locating REDD projects on the vulnerability map for Kenya

A total of 15 projects were inventoried, 10 (66.7%) REDD_agroforestry and 5 (33.3%) REDD_pure forestry projects. Majority of the projects (86.7%) were located in counties with low-vulnerability counties while the rest were found in medium-vulnerability counties (Fig. 3). No project was found in high-vulnerability counties. All the REDD_agroforestry projects were located in low-vulnerability counties while 3 (60%) and 2 (40%) of the REDD_pure forestry were located in the low and medium vulnerability clusters respectively.

In terms of project standard, majority of the projects (66.7%) operate under the VCS standard even though only 3 (30%) of the VCS projects had received VCS approval. There was no significant correlation between project standards and vulnerability indices. There was also no significant difference in project standards in relation to project type. Majority of both REDD_pure forestry projects and REDD_agroforestry projects operate under the VCS standard.

Reforestation, emission reduction and sustainable livelihoods were cited in all the projects' documents as main project objectives (Fig. 4). There was no difference between project objective and vulnerability clusters within which the projects occur. However, Wilcoxon matched pairs signed test subjecting counts of projects' objectives against project type revealed that the objectives of both REDD_pure forestry and REDD_agroforestry were statistically similar on emission reduction ($p < 0.23$), sustainable livelihoods ($p < 0.23$) and reforestation ($p < 0.23$). However, improved agricultural productivity was explicit for REDD_agroforestry projects ($p < 0.05$) while biodiversity protection was explicit for REDD_pure forestry projects ($p < 0.05$).

In terms of the forest/tree types being conserved for carbon, majority of projects (73.3%) aim to protect or conserve humid forests/trees all of which occur in the low-vulnerability cluster. Only one project (6.3%) aims to conserve dry-land forest and this occurs in the medium-vulnerability cluster. Two projects, the Kenya smallholder coffee project (low-vulnerability area) and the tree flights (medium-vulnerability area) have established/protect perennial cash crops of coffee and cashew nuts plantations respectively (Fig. 5). The number of projects targeting humid forests was significantly higher than those targeting other forest types ($p < 0.01$).

In terms of project stakeholders, the international community including international NGOs/consulting companies, international private companies and multilateral funding agencies are the proponents/funders for over 75% of the projects (Fig. 6). The local communities, national governments and national NGOs are proponents or funders to less than 20% of either REDD_agroforestry of REDD_pure forestry projects.

Characterising the relationship between project location and vulnerability

Forest cover, land ownership, water access, market access had the greatest significant influence on vulnerability and project locations (Table 2). Low-vulnerability counties, with more projects, have greater proportion of their lands under forest cover. Most households in the low-vulnerability counties also had land title deeds ($p < 0.01$). Employment and literacy rates were the main human assets that had significant implications on vulnerability and projects' location. Infrastructure/physical capital and particularly access to water, access to market, access to road and post office had significant influence on vulnerability and project locations.

Expert opinion

Interviews at the UNFCCC revealed that even though REDD policy favours poverty alleviation and emission reduction as key criteria for allocating REDD funds, additional factors such as donor and proponent interests often take precedence in locating resulting projects. Most demonstration projects are currently being implemented and funded by private for-profit companies and so investment certainty is crucial for these companies. Some socioeconomic features such as secure land tenure may reduce transaction costs for most profit seeking project proponents, argues the staff. Accordingly, the interests of the private sector in locating REDD funds remain superior currently due to their de-facto financial power. The UNFCCC has directed a variety of REDD support funds to developing countries in a bid to promote regional equality in REDD investments. So it is the responsibility of respective states to put in place measures to ensure equity in the

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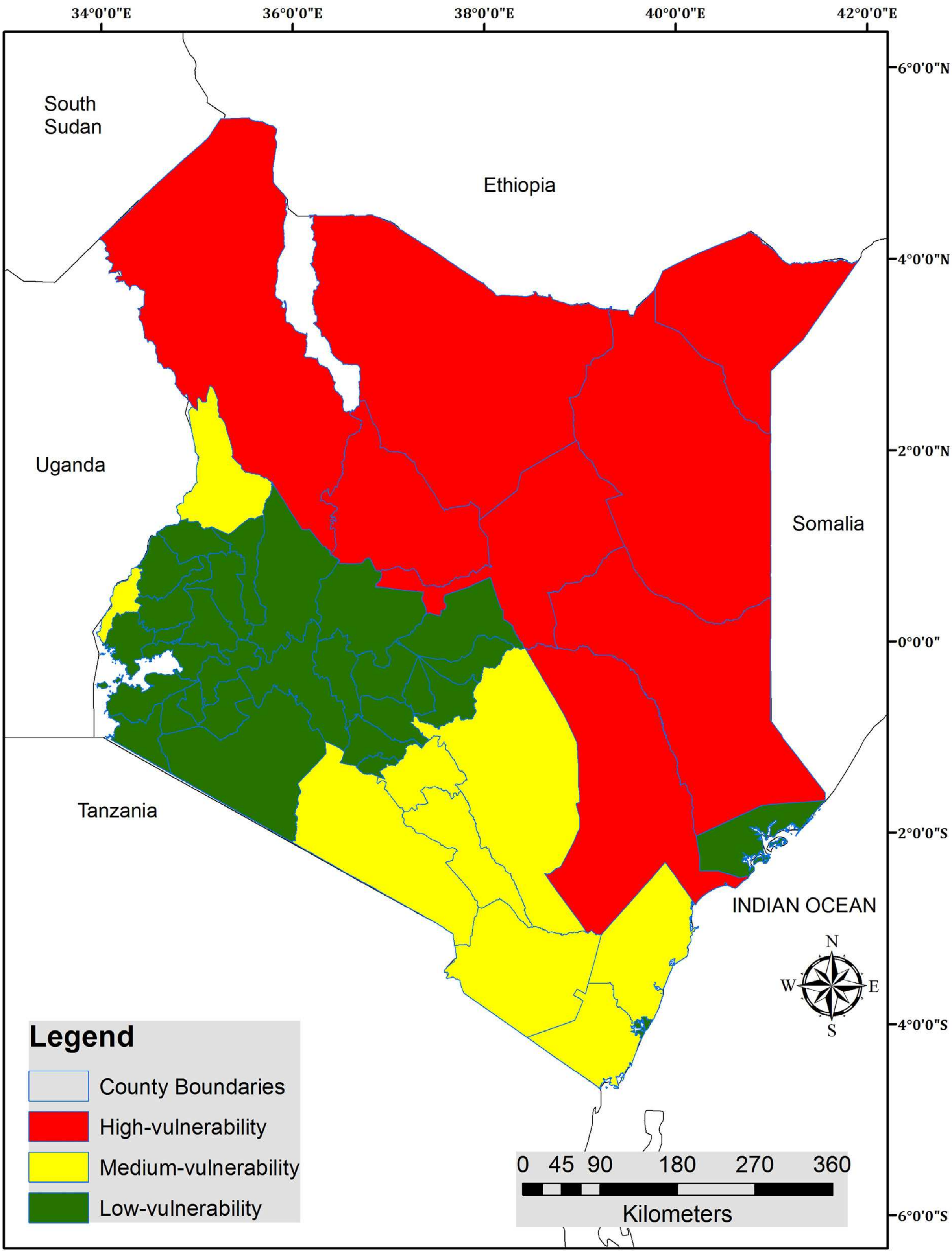

Fig. 2. Vulnerability index map for Kenya.

flow of REDD funds/projects at subnational level, argue UNFCCC staff.

The current REDD plan for Kenya tend to direct REDD funds to particular areas endowed with patches of humid forests 'water towers' and most of these are in the low-vulnerability counties. The plan has little focus on the dry-land forest areas dominating the medium to high-vulnerability areas. Interviews with relevant government staff revealed that the current national policy making process for REDD draws much of its content and support from the FCPF guidelines. The FCPF process has provisions for local

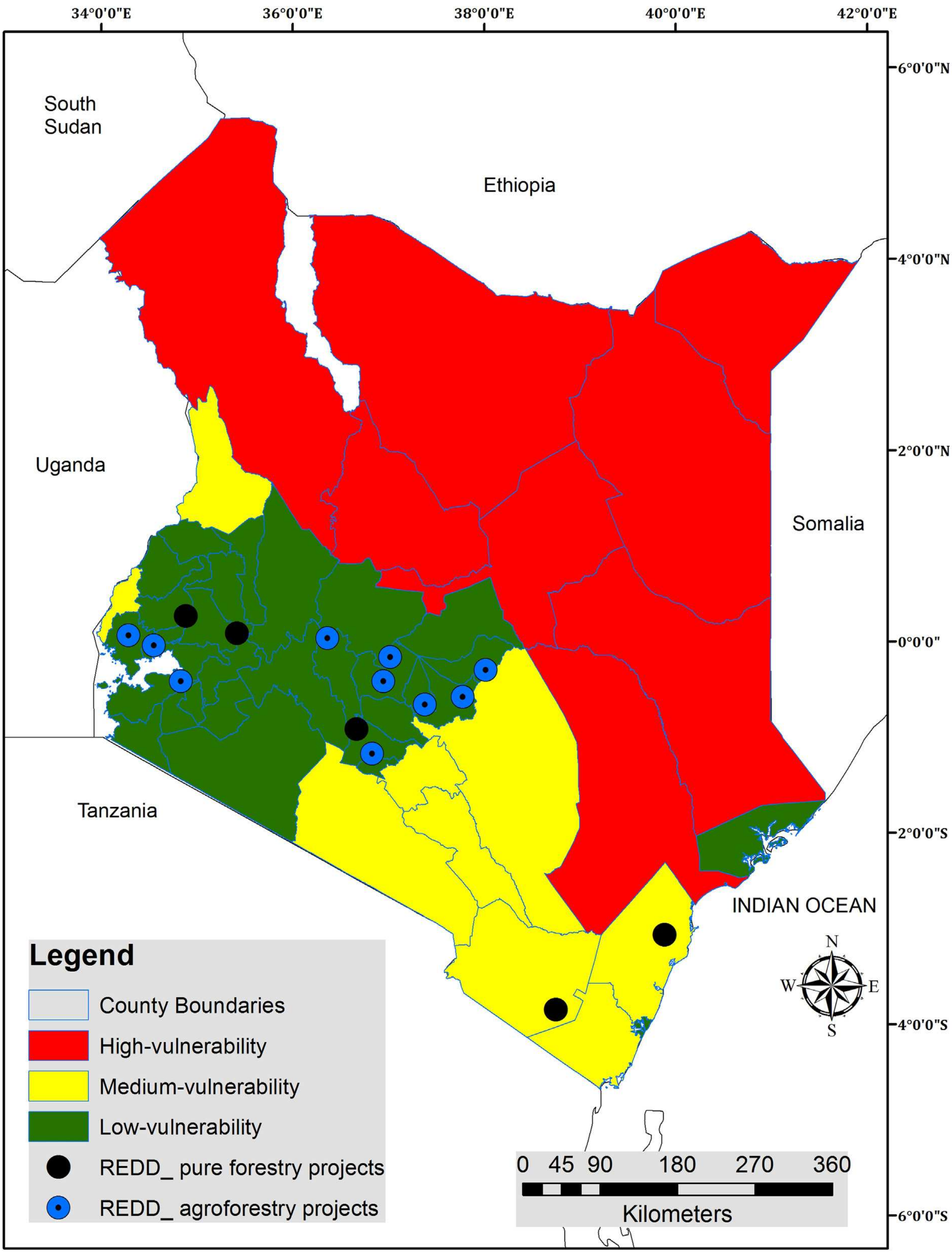

Fig. 3. Spatial distribution of REDD projects across the vulnerability index map for Kenya.

safeguards and community participation but does not emphasise subnational equity in the distributing of REDD investments. REDD staff emphasised the need for research to highlight such intra-state inequality in REDD investments (and other climate change programmes) so as to inform and influence decisions made by national, international and multilateral actors supporting REDD institutional development in specific developing counties. Experiences of specific projects revealed that local socioeconomic factors can allow projects to operate in a cost-effective manner but can also reshuffle opportunity costs for projects. As such, most of the current REDD

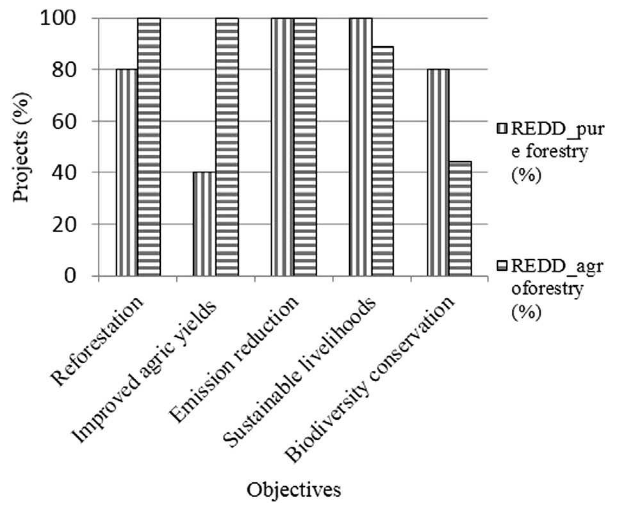

Fig. 4. Objectives of the various types of REDD projects in Kenya as stated in the projects respective design documents.

project developers prefer suitable and favourable institutional and market conditions that can safeguard their investments. These proponents additionally build on prior work with integrated conservation and development projects in particular areas where existing engagement platform reduces costs.

Discussion

Contextualising the vulnerability index map

This study relates the distribution of REDD project to vulnerability indices. The vulnerability indices are framed to reflect relative poverty status of various communities in the context of climate change. The vulnerability index map for Kenya was developed based on the IPCC conceptualisation of vulnerability as a function of exposure, sensitivity and adaptive capacity. Exposure and sensitivity indices were calculated from reasonably long term precipitation, and maize yield data respectively. However, in calculating the adaptive capacity index, only two socioeconomic indicators were applied due to data limitations. The resulting adaptive capacity indices were nonetheless significantly correlated to changes in maize yields implying the indicators considered have significant control over sensitivity of crop yields to rainfall perturbations. Due to these data limitations, the resulting vulnerability index map should be interpreted in relative rather than absolute terms and has been used here to frame the spatial flow of REDD funds.

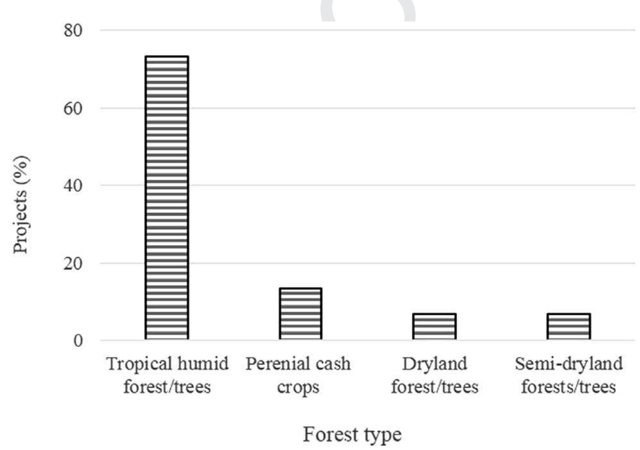

Fig. 5. Forest/tree type protected/conserved by the REDD projects in Kenya.

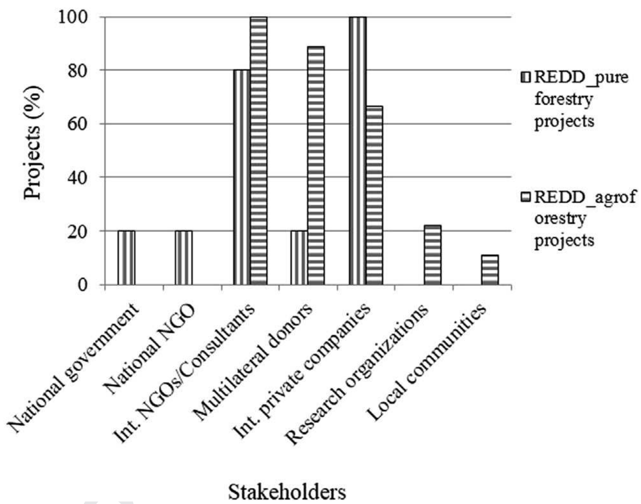

Fig. 6. Stakeholders involved in the various types of REDD projects in Kenya.

Linking vulnerability to the spatial locations of REDD projects

This study reveals that the for-profit actors, dominating the current REDD demonstrations, prefer initiating projects in low-

Table 2
Correlation coefficient of socioeconomic indicators against vulnerability indices and the corresponding causal relation to the number of REDD projects. In the final column of the table, any socioeconomic indicator which reduces vulnerability is interpreted as favourable to REDD projects and this is based on observed predominance of the projects in low-vulnerability areas.

Asset base	Indicator (%)	Coefficient to vulnerability	Causal significance to locating REDD projects
Natural	❖ Agricultural land holding (acres)	.181	.181
	❖ Proportion of area under forest	−.728**	.728**
Financial	❖ Proportion of household with non-farm income sources	−.226	.226
Human	❖ Proportion of households with employment	−.346*	.346*
	❖ Unemployment index	−.014	.014
Physical	❖ Proportion of household accessing public primary school at >5 km (bad)	.199*	−.199*
	❖ Proportion of households taking >1hr to access water (bad)	.475**	−.475**
	❖ Proportion of household accessing health facility at >5 km (bad)	.367*	−.367*
	❖ Proportion of household with access to daily market at >5 km (bad)	.476**	−.476**
	❖ Proportion of household accessing tarmac/asphalt road at >5 km (bad)	.354*	.−354*
	❖ Proportion of household with access to a post office at > 5 km (bad)	.403**	−.403**
	❖ Proportion of household with land titles	−.552**	.552**
Social	❖ Proportion of household totally affected by shocks	.436**	−.436**
	❖ Population density	−.369*	.369*
	❖ Percent contribution to national poverty	.243	−.243
	❖ Proportion of household feeling unsafe	.063	−.063

Pearson correlation test *significant at .05 **significant at .01.

vulnerability areas perceived to be favourable for better carbon returns and investment security. While international donors such as the World Bank FCPF are concentrating on supporting REDD institutions in Kenya (and elsewhere), more than three-quarters of REDD demonstration projects in the country are currently funded and managed through international private and consulting companies that aims to make profits out of the projects. Globally, for-profit seeking companies reportedly dominate the forestry offsets, producing about 84% of the offsets in 2012 (Stanley-Peters et al., 2013). These for-profit organisations were legitimised during COP 16 where the Ad hoc Working Group on Long-term Cooperative Action under the Convention, recommended a variety of funding possibilities for REDD including public, private and market based funds (UNFCCC, 2010; decision 1/CP.16). According to Sills, Madeira, Sunderlin, and Wertz-Kanounnikoff (2009) these for-profit proponents of REDD demonstrations are often keen in reducing financial risks and performance failures associated with relatively high-vulnerability areas Even though this business interest was not explicit in the project design documents we reviewed, it is arguably crucial in locating REDD demonstration projects according to the experts we consulted. A number socio-economic indicators discussed below could explain why the REDD proponents prefer to locate REDD in low-vulnerability areas.

Socioeconomic factors explaining REDD – vulnerability linkages

Forest cover (natural capital), access to water (physical capital), ownership of individual title deeds (social capital) significantly determine vulnerability and associated allocation of REDD projects.

Forest cover directly relates to carbon stock density and the quantities of carbon credit deliverable for payment. Most projects' proponents may therefore prefer to generate higher revenues by locating activities in areas with higher forest cover. Studies on the spatial targeting for REDD in Tanzania (Lin et al., 2014) and East Kalimantan Indonesia (Harris et al., 2008), revealed that forest carbon stocks is a priority criteria in allocating REDD projects. It is also argued that higher forest carbon stocks potentially increases efficiency in REDD because such areas could enhance other ecosystem services that support local livelihoods (Engel et al., 2009). Forest carbon stock is also dependent on forest types. Various forests in Kenya, range from tropical humid forests to dry-land savannah forests and are recognised under REDD (Gibbs et al., 2007). However, more than three-quarters of the inventoried projects in this study, seek to protect patches of tropical humid forests/trees occurring in low-vulnerability areas of Mt Kenya, Rift valley and western highlands but with little focus on the wider dry-land ecosystems that constitute over 75% of Kenya's vegetation cover. Only one project, 'the Kasigau Corridor REDD project', targeted a dry-land ecosystem in the Taita-Taveta County (medium-vulnerability). Dry-land ecosystems/forests reportedly store low amount of carbon stocks (.05–.7 t//ha/year) compared to the tropical humid forests that sequester 5.9 t C/ha/year (Gibbz et al., 2007). Therefore, investing in dry-land ecosystems may not generate more revenues for project proponents. On the contrary, experiences of the Kasigau project revealed that delivering carbon credits from a dry-land ecosystem provides low opportunity costs to the project thereby enhancing project's acceptance locally as a better alternative economic use for the land (Atela, 2013).

Land tenure in REDD has attracted mixed academic and political opinions about what tenure system may work well for the programme. In this study, areas where larger proportion of households own land titles, hosted more REDD projects. It has been argued that informal rights to land, as is in high-vulnerability areas, may not enable legally enforceable and credible commitment to delivering carbon offsets (Chhatre et al., 2012). Informal land rights is perceived to be more unfavourable in projects where community members themselves are the service providers, argues Gutman (2003). The debate about land tenure, however, remains elusive in light of contextual suitability and existing local systems. For instance, while secure land tenure has largely been interpreted to mean private/individualised ownership (Chhatre et al., 2012), the Kasigau project (REDD_pure forestry) has shown apparent success through communal land tenure systems as a framework for community participation, simplified negotiations and more inclusive benefit sharing (Atela, 2013). The other case example is the Kenya Agricultural Carbon Project (REDD_agroforestry) in western Kenya, which generates carbon from individual household fields yet communal use of this land is a common practice (Atela, 2012). This raises conflicts on whether farmers should allow free grazing of land during the dry season or instead conserve residues for carbon sequestration and individual benefit. Such mix of land and resource tenure arrangements may be overlooked as the commoditisation of carbon creates incentives to privatise and individualise land potentially locking out landless, tenant farmers and even women and youth (with no traditional land inheritance rights) from access and ownership of land resources. The debate on land tenure in REDD should thus not be confined to individualised titles but should be broadened to reflect the contextual suitability of different tenure systems.

Access to water is also crucial in allocating REDD projects. Areas with good access to water resources hosted more projects. Areas experiencing water/rainfall scarcity may not support projects' objective of reforestation for carbon (Zomer, Trabucco, & Van straaten, & Bossio, 2006). Additionally, water scarcity can be a challenge to REDD projects both in terms of generating carbon credits and participation time in carbon activities. For example, the Kenya Agricultural Carbon Project works with groups of farmers comprising mainly women and during dry periods, the women have to spend more time searching for water instead of implementing sustainable land management practices for carbon. In the Kasigau case where water scarcity is severe, the project has allocated part of the carbon revenues to communal water projects and this has yielded favourable perception of the project mainly because the local people perceive it to be more sensitive to local vulnerabilities relative to unrewarding state initiatives such as national Parks. The Kasigau situation shows that if projects are located in vulnerable areas, with mitigation potential, impacts may be more explicit for the local people compared to high potential areas with better economic alternatives relative to REDD. This also means that pro-poor targeting for REDD could spur greater synergies between mitigation and adaptation.

In terms of market access, low-vulnerability counties seem to have closer proximity to Kenya's economic hubs such as Nairobi, Nakuru, Kisumu, Eldoret and Kakamega and are able to access better markets for their agricultural produce at better prices. This effectively translates to better income, reduced poverty and reduced overexploitation of natural resources including forests and soil nutrients.

Conclusions: policy implications

This study focuses on Kenya as a case study to assess the spatial location of REDD projects across subnational level vulnerability indices. Findings indicate that majority of REDD projects in Kenya are hosted in relatively low-vulnerability areas where inherent socioeconomic conditions are deemed favourable to the interests of for-profit project developers. The findings coincide with the Kyoto-based CDM in which vulnerable areas were technically excluded from accessing carbon funds. Yet the UNFCCC debates on REDD have, over time, coined a generic notion that REDD is pro-poor simply because it targets developing countries. The Kenyan case shows that actors, endowed with financial resources, draw from the UNFCCC negotiation outcomes to usefully showcase REDD in 'developing countries'. However, beyond the 'developing country' tag, business interest ensues and this interest conflicts the pro-poor notion of a 'global REDD' potentially denying relatively vulnerable communities, with mitigation potential, a chance to participate and benefit from REDD funds.

In the discussion, we have highlighted the influence of assets in locating REDD projects. We have also acknowledged the ease of doing 'REDD businesses' in less-vulnerability areas. However, we have highlighted the fact that medium-high-vulnerability areas, with mitigation potential, may present some opportunities for REDD in terms of enhanced recognition of impact, low opportunity costs thereby promoting greater synergies between mitigation and adaptation. Such opportunities are realisable if REDD adopts a pro-active approach to implementation in which projects do not only target to benefit from existing well developed systems but also aim to streamline resource governance in relatively vulnerable settings. Global and national policies should support pro-active and pro-poor REDD design rules that do not confine social justice to community consultation and benefit sharing but also considers spatial equality in REDD investments.

The role of science in unveiling the opportunities associated with locating REDD in vulnerable communities is paramount. Additional research, that analyses the practical unfolding of specific projects in relatively vulnerable settings, could unveil lessons for policy makers and project proponents to consider in directing REDD investments to such areas. Emerging concepts such as reducing emission from all land uses (REALU) and the landscape approach, if explored further, could also provide opportunities for vulnerable communities to access REDD funds/projects and create frameworks for synergising mitigation and adaptation.

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