Engaging the Challenge of Climate Change: Enhancing the Role of Land Surveyors in Land use Change and Carbon Credit Markets.

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Key words: Climate Change, Land Use, Land Use Change, Forestry, Carbon Credits, Land Policy, Land Management, Land Administration.

SUMMARY

Research reveals that the land sector is a major emitter of greenhouse gases. But the land sector has also potential to reduce emissions. Different from other emission sectors like energy and transport, the land sector (in particular the rural area including forests) has the potential to also remove greenhouse gases from the atmosphere through sequestration and storage. This requires land use, land use change and forestry to be managed with respect to climate change goals. Carbon storage has the potential to generate carbon credits, which according to the Kyoto Protocol are exchangeable in a market environment. But is the market secure enough? This paper aims at analyzing the contribution of land surveyors to realizing the potential, both from a policy and management perspective (reduction and storage) and market perspective (secure carbon credits transactions).

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1. INTRODUCTION

In general, land use, land use change and forestry are major contributors to greenhouse gas emissions. Specifically, urban areas are the main centres of consumption and emissions, but also offer good opportunities for reduction and for playing an important role in climate change mitigation and adaptation, creating long term sustainability and social development. Rural areas make up a quarter of the Earth's surface and the soil and plants hold three times as much carbon as the atmosphere. What is special about rural areas is that - while climate change measures in other sectors aim at achieving a lower level of greenhouse gas emission - the land use sector is able to also remove greenhouse gases from the atmosphere through sequestration and storage.

The largest source of carbon emissions has been from fossil fuels, followed by land use change stemming predominantly from the conversion of forests to agriculture. Deforestation, or the conversion of forests to agricultural land, accounts for the loss of 13 million hectares each year, representing 4Gtons CO2*e* yearly ('*e*' stands for equivalent, bringing all greenhouse gases under 1 unit, and G stands for 'Giga' which is 1 billion tons). Planting trees, for example under REDD+ programmes, aims at restoring forests and increasing carbon sequestration.

The result of 'climate change proof' land management is a reduction in emissions of carbon dioxide or greenhouse gases called a 'carbon offset'. The Kyoto Protocol provides for these carbon offsets to be used by governments and private companies to earn tradable carbon credits that can be traded in a marketplace.

This paper aims at collecting some relevant facts about the relation between climate change and land use, with the purpose to review what land surveyors can contribute. First, in section 2 we collect these facts. In section 3 we formulate the role of surveyors. In section 4 we conclude.

2. ENGAGING THE CHALLENGE OF CLIMATE CHANGE THROUGH LAND USE, LAND USE CHANGE AND FORESTRY ('LULUCF')

Land Use, Land Use Change and Forestry are normally abbreviated in the Climate Change literature using the acronym 'LULUCF'. Based on a literature review, we describe the role of land use, land use change and forestry in subsequently the urban areas (par. 2.1.), rural areas (par. 2.2.), forests (par. 2.3.), coastal zones (par. 2.4.), the Kyoto compliance market (par. 2.5.), the Kyoto voluntary market (par. 2.6.), whether a carbon credit is a property rights (par. 2.7.), current overcapacity problems (par. 2.8.) and a conclusion (par. 2.9). The aim of this section is to provide a sufficient background to embark on a description of how land surveyor's roles can be enhanced, in section 3.

2.1. Urban Areas

Urban areas are main centres of consumption and greenhouse gas emissions. While in general emissions have grown by 70% between 1970 and 2004 (in 2004 a total of 49 Gtons CO2*e*), with buildings counting for 3.9, energy contributing 12.7, and transport 6.5 Gtons (IPCC, 2007b). Regarding consumption of energy, buildings count for 30-40% of the total energy consumption in western countries, of which 50% refers to indoor air conditioning (heating and cooling) (IPCC, 2007a).

However, cities also provide the opportunity to play a role in climate change mitigation and adaptation, creating long term sustainability and social development. Much of the necessary action has to take place at the level of cities, where half of the world's population lives, and can result in lower energy use, less pollution and greater resilience. To achieve these 'low carbon cities', 'post carbon cities', 'transition towns', or 'smart cities', greenhouse gas abatement, energy conservation strategies and land use planning need to be connected.

In general, regarding urban spaces two kinds of measures are proposed.

First, cities should be more compact. This relates to the control of urban sprawl, densification processes, regeneration of rundown urban areas, the consolidation of already urbanized zones, creating higher density housing, the infill of vacant lands, extension of existing buildings, the reduction of travel demands, more efficient public transport, and the implementation of district heating. This is a matter of urban design.

Second, urban spaces should be appropriately designed. This is related to mixed use areas, green spaces, better orientation of buildings, improved solar gains, sunlight availability, site layout, proximity of residences to facilities and services, access to workplaces, land use diversity and urban quality (Zanon, 2013).

Cities can thus begin to adapt to the impacts of climate change via effective urban management. Planning and land use controls can prevent people from building in zones at risk of flooding and landslides. Guidelines and regulations can increase resilience. Governments can design infrastructure that is climate proof. Likewise government can mobilize stakeholders to contribute their technical and even financial resources towards joint endeavors. Such adaptation measures make economic sense (UN Habitat, 2002). Climate change mitigation and adaptation need thus to be systematized and systematically incorporated into urban planning practice (Wamsler, 2013).

Regarding houses, modern building design includes low carbon running costs while 'maintaining comfort'. Super insulation, high performance windows, heat recovery systems, thermal storage are to be included in climate proof design principles. In order to monitor the energy use, several countries have introduced environmental rating of buildings ('*energy labelling'*). As more than 80% of energy used in households is dedicated to space heating and cooling, large savings are expected to be gained in the housing stock.

Special attention needs to be dedicated to the urban dwellers in low and middle income nations. Hundreds of millions of urban dwellers have no all-weather roads, no piped water supplies, no drainage systems and no electricity supply; they live in poor quality homes on informal or illegally occupied or subdivided land, which inhibits any investment in more resilient buildings and often prevents infrastructure and service provision. A high proportion of them are tenants, with very limited capacities to pay for housing, and their landlords have no incentive to invest in better quality buildings. Housing policy, infrastructure policy, housing finance systems, health care and reducing environmental health risks, urban planning should focus on providing low income groups with safer, legal alternatives to informal settlements. Land use management should protect and enhance natural buffers and defense for cities and their surrounds (Satterthwaite, 2007).

Cities in the emerging countries are among those that face the most difficult challenges. They often have very limited capacity and need the assistance of the international community to help protect the lives and livelihoods of their peoples, while attaining their development goals (UN-HABITAT, 2010). Many of these same places are also among the more vulnerable to climate change and natural disasters.

City dwellers with weak land tenure (such as in slums) might suffer substantially from climate change effects, in particular when located near coasts or rivers subject to flooding. On the other hand, investments are needed by owners and users to make buildings 'climate proof'. Where tenants do not have secure tenure, a question is whether there is a sufficient incentive for tenants to invest in improving the quality of house construction (Quan and Dyer, 2008).

The keywords for our professional domain are ‘urban management’ and ‘urban land management’ and ‘secure urban land tenure’.

2.2. Rural Areas

Sustainable agricultural production plays a role in the adaptation and mitigation of climate change, because agriculture (a) is an important emitter of greenhouse gases, (b) has the highest potential for reducing emissions through carbon stocks and (c) is the sector that is most affected by climate change (Quan, 2008).

More than 30% of all greenhouse gas emissions arise from the land use sector. Livestock-related emissions of carbon and methane account for 14.5% of total greenhouse gas emissions, more than the transport sector. Deforestation, agriculture and livestock grazing are the major land use changes that increase the release of carbon into the atmosphere (31% of human/induced GHG emission of in total 49 Gtons CO2*e* thus 15 Gtons CO2*e*) (Steinfield, 2006). Land use changes and the burning of fossil fuels such as oil and coal are the two dominant sources (27.7 Gtons) while agriculture emits 6.5 Gtons and deforestation emits 8.5 Gtons (IPCC, 2007a, Scherr, 2009)

What is special about the land use sector is that - while climate change measures in other sectors aim at achieving a lower level of greenhouse gas emissions - the land use sector is able to also remove greenhouse gases from the atmosphere through sequestration and storage. Carbon pools are in oceans and the earth’s crust, but also in tree biomass, vegetation, roots, forest litter, dead wood, and soil. Unless the carbon is locked in forest biomass over the long term, it will contribute to the growing greenhouse gases in the atmosphere with long-term climate consequences (Barnes, 2009). About 1,600 billion tons (= 5,872 Gtons CO2*e*) of this terrestrial carbon is in the soil as organic matter; some 540-610 Gtons in living vegetation, such as long-living forests, grasses and palms. IPCC estimates that agriculture has a sequestration potential of 4.0 - 4.3 billion tons of carbon dioxide equivalents a year by 2030 (IPCC, 2007a).

What should be done? From (Scherr, 2009) we derive the following 5 strategies.

Enriching soil carbon. The soil, being the third largest carbon pool on earths’ surface, can be managed aimed at reducing emissions by minimizing tillage, reducing use of nitrogen fertilizers and the prevention of erosion. Soils can store the carbon captured by plants from the atmosphere by building up soil organic matter, which also had benefits for crop production. Adding ‘biochar’ (biomass burned in a low-oxygen environment) can further enhance carbon storage.

Farming with perennials: perennial crops, palms and trees constantly maintain and develop their root and woody biomass and associated carbon, while providing vegetative

cover for soils. There is large potential to substitute annual tilled crops with perennials, particularly for animal feed and vegetable oils, as well as to incorporate woody perennials into annual cropping systems in agroforestry systems

Climate-friendly livestock production: rapid growth in demand for livestock products has triggered a huge rise in the number of animals, the concentration of wastes in feedlots and diaries, and the clearing of natural grasslands and forests for grazing. Livestock related emissions of carbon and methane now count for 14.5 % of total GHG emissions, more than the transport sector. A reduction in livestock numbers can help, including rotational grazing systems manure management, methane capture for biogas production, and improved feeds and feed additives.

Protecting natural habitats: 4 billion ha forests and 5 billion ha natural grasslands are a massive reservoir of carbon-both in vegetation above ground and in root systems below ground. Farmers should be encouraged to maintain natural vegetation through product certification, payments for climate services, securing tenure rights, and community fire control.

Restoring degraded watersheds and range lands: degradation has not only generated a huge amount of GHG emissions, but local people have lost a valuable livelihood asset as well as essential watershed functions.

Rural areas are major emitters of greenhouse gases, both from soil fermentation with inorganic fertilizers and applied manure, gases from food digestion in cattle, biomass burning, paddy rice production with anaerobic decomposition, livestock manure, and deforestation in particular for agriculture and livestock (Scherr, 2009). What is unique is that the agricultural sector is the only sector able to remove greenhouse gases from the atmosphere.

This is especially important for informal tenures such as customary land, tenancy, and informal settlements, where the climate challenges are great. Improving tenure security in these areas can have a significant impact on the desire and ability to implement climate change mitigation and adaptation (Quan, 2008).

Key words in our professional domain are similar to the urban context - ‘rural management’, ‘rural land management’ and ‘secure rural land tenure’.

2.3. Forestry

The largest source of carbon emissions has been from fossil fuels, followed by land use change stemming predominantly from the conversion of forests into agriculture.

Deforestation or the conversion of forests into agricultural land accounts for the loss of 13 million hectares each year. Latin America and Africa have suffered the largest net loss of forests, estimated at 4.3 and 4.0 million hectares annually respectively from 2000 to 2005 (FAO, 2005). This loss represents emission of 4 Gtons CO2*e* annually.

In particular, carbon stock in live biomass is capable of removing greenhouse gases from the atmosphere. Net carbon stock is estimated at 1,036 Gtons a year; globally. Net carbon stocks in forest biomass decreased by about 4 Gtons annually between 1990 and 2005 (IPCC, 2007b). To cope with deforestation in general, many countries attempt to pursue a forest policy that restricts legal logging and fights illegal logging, such as in South Africa, Uganda, Nicaragua, Surinam, Brasil, etc. (FAO, 2010).

The UN-programme to reduce greenhouse gas emissions from deforestation and forest degradation (REDD and REDD+) aims at planting 4 million hectares of forests to partly compensate the 13 million hectares that are cleared annually. Ownership rights over land and over the carbon sequestered, along with the management control of REDD+ projects, are the most critical elements to be accounted for in REDD+ projects (Quan, 2008). Protecting the tenure security of vulnerable forest peoples in critical and one option is to link systematic or sporadic land titling programs to REDD+ projects.

Lack of recognition of existing ('de facto') property rights over forest areas and the allocation of forest land to commercial users by governments have led to widespread deforestation as a result of uncontrolled logging and conversion of forest land to other use (Quan, 2008). Environmental externalities are often the result of property rights not being clearly specified, and of insecure tenure. Where property rights are not documented, or are not enforced, excessive forest clearing can occur. Therefore, insecure land tenure can undermine the incentives to improve productivity and conserve forests (UN-HABITAT, 2010).

Key words for our domain are 'forest management', 'forest land management' and 'secure forest tenure'.

2.4. Coastal Zones

A total of 634 million people (10% of the world's population) are estimated to live in the Low Elevation Coastal Zone (the coast less than 10 meters above sea level), 360 million of whom are in urban areas. Especially for the urban poor, retreat from hazard-prone areas is not possible, because of high population densities and shortage of suitable land. The risks faced by the urban poor relate substantially to the pressures causing urbanization, problems of inadequate land use planning and in addition the lack of secure tenure (Quan, 2008).

Small Island Developing States ('SIDS') are particularly affected as most urban areas lie along coastlines and tend to be low-lying and densely populated. Sea-level rises and an increase in the frequency and severity of natural disasters have led some governments to consider relocating some communities or families in urban areas away from coastlines.

There is a likelihood of increased displacement of urban residents particularly in coastal areas, and there will be a need for enhanced systems for land delivery, and systems for land use planning in both urban and rural areas. These regions will require improved systems for land use planning, flood risk management, drainage, and coastal protection but also for land access for resettlement, and to facilitate both planned and spontaneous migration including both temporary and permanent displacement as a result of high flood events (Quan 2008, Correa, 2011).

However, resettlement decisions are complex and can have many implications. Conflict can occur if there is not agreement by the hosting legal proprietors, inadequate provision of infrastructure, or if resettlement occurs in areas of hazard risk. People resettled also need security of tenure (Correa, 2011).

The main land policy implication (in coastal areas) is intensified resettlement planning and a stronger role for the state in land use planning on areas at risk and available for resettlement. This requires investments in a land inventory and land occupation surveys in both potential resettlement areas and areas at risk of loss, which in turn requires development of dedicated land information systems. Public land acquisition may be needed to impede occupation in at-risk areas, and to acquire land for resettlement and infrastructure. However, this is also likely to require schemes for land to be shared or transferred from private ownership, and to promote land rentals and the good use of available public land (FIG, 2010; Quan, 2008).

Key words for our professional domain are 'coastal zone management', 'secure land tenure' and 'disaster risk management'.

2.5. Kyoto Protocol and Compliance Markets

Articles 6, 12 and 17 of the Kyoto Protocol establish a market for trading of 'assigned emission units' (AAU's). This is known as the 'compliance market', structured to facilitate the trade in emission rights. Article 17 allows countries that have 'assigned emission units' to spare and to sell their surplus credits to countries that are over their targets. This system is often called the 'cap-and-trade system'.

The Protocol also offers an opportunity to generate Certified Emission Reduction Units (CERs) in cooperation with developing countries in carbon sequestration projects ('Clean Development Mechanism').

The largest emission trader is the EU ETS (European Emission Trading System) which started in 2005 with its cap-and-trade system. Under this system a limit or allowance is set on the amount of carbon a company can emit. If the allowance is exceeded, the company then buys an allowance or credit elsewhere or faces heavy fines. The seller, in turn, is rewarded for having reduced emissions. Other emission trading regimes under the formal market include the Australian state of New South Wales and the UK ETS. Since the US has not ratified the Kyoto Agreement, it is not bound by these markets; however, both the Chicago Climate Exchange (CCX) and the newly emerged Regional Greenhouse Gas Initiative (RGGI) are considered important voluntary markets (Barnes, 2009). Although the markets suffer from the financial crisis today, the value in 2011 of the global market amounted 176 billion $, representing an emission volume of 10 Gig tons of CO2e (World Bank, 2012).

2.6. Kyoto Protocol and the Voluntary Market

Articles 3.3 and 3.4 of the Kyoto Protocol provide for the use of greenhouse sinks (carbon sequestration and storage in soils and vegetation) to be used by countries to fulfill their obligation to reduce greenhouse gases. Apart from the compliance market, a retail offset market has emerged, with a focus on voluntary participation by parties not bound by specific caps or regulations. Greenhouse gas emissions can be offset by investing in projects that provide emission reductions elsewhere in the form of 'Voluntary Emission Reduction Unit's (VER's); critically, the voluntary market is still unregulated in that it has no market standards (Harris, 2007).

Although impacted by the financial crisis, the value of the voluntary market in 2012 amounted up to 523 million $ representing 101 Mtons of CO2e (Peters *et al*, 2013).

The voluntary carbon credit market leads to opportunities for measures such as carbon farming (Harper *et al*., 2007), to generate tradable carbon credits through (e.g. in Australia) reduction of livestock density, removal of wild grazing animals such as goats and rabbits, conversion from cropping to grazing, conversion from conventional to no-till cropping, re-vegetation (trees, fodder shrubs) and forestry development. Measures to materialize the potential of carbon sinks include reforestation, grazing land management, cropland management, and re-vegetation.

2.7. Is Carbon Credit property?

Whether an emission rights creates a property right is questionable. Apparently, an emission right knows exclusivity, has value, and can be traded. A UK Court considered emission rights therefore as a property right as did the International Accounting Standards Board, the US Congress, and IIED. The West Australian Carbon Rights Act 2003 provides for a 'title for the carbon in a sink, separate from that of the land, which provides a legal base for ownership and trading'. On the other hand, the Kyoto Protocol insist that no 'rights' are created (Marrakech Accords, 2001); the US Clean Air Amendment 1990 says the same regarding US carbon credits, and the Australian Securities and Investment Act 2001 says that the Australian Carbon Credit Units (ACCU's) are financial products and with no property rights. If the marketing of carbon credits however requires a 'title for a carbon sink', then we should consider those rights as separate from the property title for the land (e.g. 'unbundling of property rights') (Wallace, 2006a, 2006b).

To date, it is recognized that transactions in voluntary carbon credits such as occur in Australia, Europe and North America are not formally recorded. As cited earlier, Harris (2007) considers the voluntary retail market to be unregulated; in order to increase 'market integrity and to avoid that emission rights are sold more than once, formal registration should be implemented; aside from the credibility gained, this registration could make the market more fungible'. Harris refers to existing registers such as Triodos Bank's Climate Clearinghouse register, the Greenhouse Gases Register of the Environmental Resources Trust (ERT), and a register managed by the Bank of New York.

In addition, a report for the House of Commons in 2007 reveals great concerns about the voluntary market. The report characterizes the voluntary market as a market for 'carbon cowboys', in which it is not really clear what the object of trade is and what the legitimacy of the trade is. Regulation is needed, says the Report (HoC, 2007).

Indeed, fraud has been a big ongoing problem with emissions trading. EU already lost 5 billion US$ to carbon trading value-added tax fraud. The mafia is laundering money in Italy through renewable schemes, and after one tax loophole was closed, the market in Belgium dropped 90% (The Australian, 31 July 2013).

(Barnes, 2009) argues that five fundamental questions should be answered regarding carbon credits, namely (1) what rights, (2) whose rights (3) when were they acquired and whet is the duration, (4) how were they acquired, and (5) what are the spatial dimensions (location, extent, boundary dimensions). He believes a carbon cadastre is necessary (Barnes, 2011).

Key words from par. 2.5-2.7 for our professional domain are 'security of carbon credit rights', 'secure carbon transactions' and 'appropriate recording'.

2.8. Problems in the Carbon Credit Market.

Currently the price for carbon in the ETS has been collapsed, because of reduced industrial demand and issuing by the EU of too many allowances. Simply, there is overcapacity, reducing the price to about 1 euro/ton. Carbon exchange markets have postponed trade. The ETS problem might easily influence the markets worldwide, observes The Economist of 20 April 2013. Therefore, questions are asked whether carbon trading is indeed the proper solution to climate change (REDD, 2013).

2.9. Conclusion

This overview demonstrates that land use, land use change and forestry require land management that includes specific mitigation and adaptation measures. Urban, rural, forest and coastal areas require specific approaches, whether it concerns urban and building design and their spatial effects, farming and livestock production, restoring degraded lands, forest management and afforestation, coastal management and disaster resilience. The unique characteristic that land and forestry can also remove GHG from the atmosphere allows reduction of emissions and the generation of tradable carbon credits in addition to the cap-and-trade system, which entails market security problems. In all cases, aspects of land policy, land management and land administration are at stake and consequently the involvement of land surveyors. In the next section we aim at making this role more explicit.

3. ENHANCING THE ROLE OF LAND SURVEYORS

We argue that this professional involvement is manifest in three fields, namely land policy (par. 3.1), land management (par. 3.2.) and land administration (par. 3.3.).

3.1. Land Policy

What are the challenges for a relevant land policy? A land policy aims at 'providing legal and socio-economic prescriptions that dictate how access to land and access to land related opportunities are to be allocated' (EU, 1996). The challenge to make urban areas reduce their emissions can potentially be met when policy choices include measures as mentioned in paragraph 2.1. Three aspects appear to be at stake. The first is better urban design, so that compact cities can develop, with urban sprawl control, regeneration of urban areas, infill of vacant lands, and more efficient transport etc. The second is the appropriate design of urban spaces, so that mixed land use is possible, better orientation of buildings to capture solar energy, sunlight availability etc. Third, there is the aspect of modern building design that includes low carbon running costs. In this way, 'low carbon cities' can be achieved.

Rural and forests areas require policy choices on how to increase soil carbon storage, restoration of degraded lands, application of cultivation methods that improve carbon sequestration (such as more rice cultivation, livestock and manure management), better forest management and better land-use management.

The main land policy implication in coastal areas is intensified resettlement planning and a stronger role for the state in land use planning in areas at risk and available for resettlement and the policy choices on how to achieve disaster resilience.

Enemark (2012) notes that key policy issues to be addressed in relation to climate change also involve avoiding a concentration of the population in hazard-prone areas and improving the resilience of existing communities to cope with the impact of future climate change. In a practical sense, building codes can help to mitigate the damage of disasters (e.g. floods and earthquakes), and consideration of resettlement of hazard-prone communities.

Other aspects involve protecting the more vulnerable (women, children, the elderly, the very poor, ethnic and religious minorities) from being dispossessed from their lands. Government and customary groups may need to work together, and closer ties developed between land agencies and those responsible for disaster risk management and climate change adaptation.

Key policy areas according to (UN Habitat, 2010) comprise protecting steep slopes from non-sustainable agricultural practices, protection of coastal zones and wetland areas, consolidation of fragmented lands, sustainable management of rented land, unequal land distribution, land degradation, inefficient land use , tenure insecurity in relation to urban expansion, tenure security for slum dwellers, tenure security and investment capacity, tenure form in areas with customary tenure, social and environmental costs of elite capture of land reforms using tools like land rights & registration, land use planning, land management and land administration, land information, land law enforcement, land tax and land valuation.

The work of the land surveyor is characterized by interdisciplinary approaches (e.g. land challenges, property rights, disaster risk management, precise measurements, assessment of future vulnerability) (FIG, 2010), so that land surveyors are capable to incorporating climate change into current land policies, adopting standards for energy use, emissions, carbon stock potential, identifying prone areas (e.g. sea level rise, drought, flooding, fires), introducing carbon footprint assessments in relation to land use developments, controlling building standards and emissions in relation to climate change, improving resilience of existing ecosystems vulnerable to climate change (Enemark, 2011).

3.2. Land Management

The Kyoto Protocol requires societies to respond to climate change by reducing greenhouse gas emissions ('mitigation') and coping with the changes ('adaptation'). The IPCC report 2007 specifically summarizes various options. Regarding mitigation measures related to land and housing, the report suggests e.g. increased production and use of biofuels, reduction of transport needs by means of climate-proof land-use planning, energy-efficient houses and commercial buildings by the establishment of energy labeling and building codes. Regarding adaptation measures, the report suggests various measures inlcuding expanded rainwater harvesting, water storage, crop variety, improved land management to achieve erosion control and soil protection, the construction of seawalls and storm barriers, dune reinforcement, land acquisition and creation of marshlands and wetlands as a buffer against sea level rise and flooding.

While recognizing the various sectors in society have a role in finding solutions for climate change (for instance the transportation sector, housing sector, and the agricultural sector) the coordinating mechanism is still spatial planning especially at the local level (Biesbroek *et al*, 2009). This explains the role of local governments as they have control over 'areas that crucially affect greenhouse emissions, such as transportation, energy use, land use regulation and environmental education' (Puppim, 2009). The role of spatial planning is even more important as the reduction of transport related emissions has a direct relationship with the higher density of land use, resulting in less transport activity both for passengers and freight (Grazi *et al*, 2008).

The effects of climate change and variability are felt through changes in natural eco-systems, land capability and land use systems. As a result, land issues and policies are key considerations for adaptation planning, which will need to strengthen land tenure and management arrangements, particularly in high hazard-risk environments (Quan, 2008).

The effects of climate change can result in changes to livelihoods, human settlements, land use patterns, and tenure systems. The manner in which decisions about access to, use of, and control over resources are implemented and enforced, as well as the way that competing interests in resources are managed, is as central to the success of climate change adaptation and mitigation, as it is to livelihoods of people. The flexibility of customary tenure systems may in fact be ideal for adaptation purpose (Arial, 2011).

Over the last few years there has been considerable focus on land governance in the Surveying community and the land sector. Two significant developments have been the *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security* developed by UN FAO (2012), and the *Land Governance Assessment Framework* (2012) developed under the supervision of the

World Bank. Together they provide surveyors with a structured framework to assess responsible governance, and guidance to States on how to improve their governance.

Land surveyors can engage themselves in developing climate proof land management approaches by connecting the principles of good land governance with the management measures to mitigate and adapt climate change.

3.3. Land Administration

Sustainable land administration systems should underpin climate change adaptation and mitigation and the prevention and management of natural disasters (Enemark, 2012). The World Bank (2011) argues that one of the ways states can build resilience in vulnerable groups is to strengthen land administration and consider improving security of tenure and service provision in informal settlements.

This means that in addition to the appropriate registration of land tenure and cadastral geometry, additional information is required about the environmental rating of buildings, energy use, current and potential land use related to carbon stock potential and greenhouse gases emissions, and clearer definitions of various land types related to the application of various legal regimes (for example, what exactly is 'idle' land?), flood and storm prone areas, salinization rates and transport indicators. This information may not necessarily be recorded in the land administration system itself, but at least connected with it, so that a strong link with private and public rights to land remains in existence.

Where carbon credits are considered as 'unbundled' property rights, with a separated carbon credit title, land administration systems should be able to record or register such rights and to attach appropriate geometric attributes, to make those titles accessible for trade in the carbon credit market.

Land administration systems also have to fulfill their most vital purpose, namely to provide land tenure security to right holders, with a focus on the poor, the vulnerable and indigenous peoples, in order to safeguard their land rights. For example, this is important where there are demands for land for purposes of large-scale biofuel production or afforestation for carbon sequestration. Another role is to provide information about tenure, value and use of land when governments want to encourage changes in livestock, crop production, conversion from arable land to grazing land, from tillage to no-tillage cropping, reforestation and combating degradation of soils though sound land-use planning and management.

When governments' want to apply taxation as a measure to achieve climate change objectives, a function of mature and effective land administration systems is to provide

relevant information about taxable objects, taxable values and taxable persons, including earlier mentioned indicators regarding energy use.

When governments' need lands to realize certain land use (water storage, carbon sinks), land administration systems should provide information about right holders to be compensated in the land acquisition process, in such a way that people's land rights are respected and the risk of eviction is avoided.

Land administration systems have the potential to assist in formally recognizing and recording both *de jure* and *de facto* rights to land and resources. REDD (Reducing emissions from deforestation and forest degradation), REDD+ and VCM (Voluntary Carbon Market) guidelines provide limited requirements regarding how project beneficiaries are identified and how property rights are recorded. That gap can be bridged by land administration systems, by providing mechanisms for project boundary demarcation, cadastral and participatory mapping, mapping social tenure and overlapping rights, and certification (Mitchell *et al*, 2011).

Climate change reinforces the urgency of scaling up the delivery of secure land tenure over land and natural resources. Therefore the use of low-cost decentralized systems of documentation and, where possible, we recommend building on functional informal systems. Given the high costs of land titling schemes involving full cadastral surveys of large numbers of small plots, and often complex administrative procedures, low cost methods of land survey and registration need to be introduced, together with a diversity of land tenure (Quan, 2008).

Land surveyors have the capacity to design, develop and maintain such land administration systems facilitating long term sustainability and social development.

4. CONCLUSION

The role of land use, land use change, and forestry in mitigating and adapting climate change is manifest. It requires appropriate land policy choices, land management approaches and the underpinning land administration systems. The generation of compliance and voluntary carbon credits with the goals of managing greenhouse gas emissions, facing legal security problems, might require the active engagement of land surveyors. This depends on whether carbon credits are considered as property. The involvement of our profession requires land surveyors capable of including land related issues in a wider climate change policy discussion, adopting climate change related goals and solutions in the management of urban, rural, forest and coastal lands and the design, development and maintenance of appropriate supportive land administration systems.

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