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P. van der Molen & D. Mitchell

To cite this article: P. van der Molen & D. Mitchell (2016) Climate change, land use and land surveyors, Survey Review, 48:347, 148-155, DOI: [10.1179/1752270615Y.0000000029](https://doi.org/10.1179/1752270615Y.0000000029)

To link to this article: <https://doi.org/10.1179/1752270615Y.0000000029>



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Published online: 23 Feb 2016.



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# Climate change, land use and land surveyors

P. van der Molen\*<sup>1</sup> and D. Mitchell<sup>2</sup>

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 primary at presenting the subject matter as a synthesis of extant literature. Secondary, the paper shows interfaces with the land surveyor's profession namely land management and land administration.

**Keywords:** Climate change, Land use, Land surveyors

## Introduction

In general, land use, land use change and forestry are major contributors to greenhouse gas emissions (IPCC, 2000).

*Urban areas* are the main centres of consumption and emissions. However, these areas offer good opportunities for reduction of emissions and for playing an important role in climate change mitigation and adaptation. When doing so, urban areas can create long-term sustainability and social development.

*Rural areas* make up a quarter of the Earth's surface. 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.

*Forest areas* are prone to deforestation, causing major greenhouse gas emission, but have the large potential for carbon sequestration through photosynthesis.

*Coastal zones* are of special interest because it is their challenge to cope with sea level rise.

The largest source of carbon emissions has been from fossil fuels, followed by land use change. Land use change stems predominantly from the conversion of forests into agriculture. Deforestation accounts for the loss of 13m ha each year, representing 4 Gtons CO<sub>2e</sub> yearly ('e' stands for equivalent, bringing all greenhouse gases under 1 unit, and G stands for 'Giga' which is 1bn tons). The planting of trees, for example under REDD+ programs, aims at restoring forests and increasing sequestration of carbon.

The result of 'climate change-proof' land management is a reduction of emissions of carbon dioxide or

greenhouse gases called 'carbon offset'. The Kyoto Protocol has provisions, which facilitate the use of these carbon offsets by governments and private companies to earn carbon credits that can be traded in a market place.

Land surveyors have a lot to do with land use and land use change [International Federation of Surveyors (FIG), 1991, 2004]. This paper primary aims at collecting the facts about the relation between climate change and land use, relevant for land surveyors. The paper includes a part on the markets for carbon credits in case land use management results in carbon storage. At the end of the paper, the authors aim at observing interfaces with the land surveyor's profession.

## About the relation between climate change and land use

In the climate change literature, 'land use, land use change and forestry' are normally abbreviated with the acronym 'LULUCF' (IPCC, 2000). Based on a literature review, the authors describe the role of land use, land use change, and forestry in subsequently the urban areas, rural areas, forests, and coastal zones. The aim of this section is to provide a sufficient background to identify interfaces with the land surveyor's profession.

### Urban areas

Urban areas are main centres of energy consumption and greenhouse gas emissions. In general, emissions have grown by 70% between 1970 and 2004 (in 2004, a total of 49 Gtons CO<sub>2e</sub>). In urban areas, emissions from buildings count for 3.9, from energy generation for 12.7, and from transport for 6.5 Gtons, thus together 47% of the total [Intergovernmental Panel on Climate Change (IPCC), 2007b]. Regarding the consumption of energy, buildings count for 30–40% of the total energy consumption in western countries (IPCC, 2007a).

However, cities also provide an opportunity to contribute to climate change mitigation and adaptation,

<sup>1</sup>University of Twente, Geoinformation Science and Earth Observation, Hengelose straat 99, Enschede, The Netherlands

<sup>2</sup>RMIT University, Melbourne, Vic., Australia

\*Corresponding author, email p.vandermolen-2@utwente.nl

which might create 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 which might result in lower energy use, less pollution and greater resilience (IPCC, 2014a). To achieve these, 'low carbon cities', 'post-carbon cities', 'transition towns', or 'smart cities' (as they are called in literature) greenhouse gas abatement, energy conservation strategies, and land use planning need to be connected (UN Habitat, 2010).

In general, regarding urban spaces globally two kinds of measures are proposed in the literature.

First, cities should be more compact. This relates – for example – to the control of urban sprawl, to densification processes, regeneration of rundown urban areas, the consolidation of already urbanised zones, the creation of higher density housing, the infill of vacant lands, extension of existing buildings, the reduction of travel demands, more efficient public transport, and to the implementation of district heating. This is a matter of urban design (IPCC, 2014a).

Second, urban spaces should be appropriately designed. This relates – for example – to mixed use of areas, creation of 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 and Veronesi, 2013).

Cities therefore may begin to adapt to the impacts of climate change via effective urban management. Planning and land use control 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, governments can mobilise stakeholders to contribute their technical and even financial resources towards joint endeavours. Such adaptation measures appear to also make economic sense (UN Habitat, 2010). Climate change mitigation and adaptation need thus to be systematised and systematically incorporated into urban planning practice (Wamsler *et al.*, 2013).

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

Special attention needs to be dedicated to 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, illegally occupied or subdivided land, which inhibits any investment in more resilient buildings. Often this also prevents infrastructure and service provision. A high proportion of the dwellers are tenants, with very limited capacities to pay for housing, while their landlords have no incentives to invest in better quality buildings. Housing policy, infrastructure policy, housing finance systems, and health care should therefore team up with urban planning in providing low income groups

with safer, legal alternatives to informal settlements. In addition, land use management should protect and enhance natural buffers and defense for cities and their surrounds (Satterthwaite *et al.*, 2007). Cities in the emerging countries are among those that face the most difficult challenges. They often have very limited capacity and they need the assistance of the international community to help to protect the lives and livelihoods of their peoples, while attaining their development goals (UN Habitat, 2010). Many of these cities are also among the places most vulnerable to climate change and related natural disasters. City dwellers with weak land and housing tenure (such as in slums) might suffer substantially from climate change effects, in particular when they are located near coasts or rivers subject to flooding. In similar vein, investments are needed by owners and users to make buildings 'climate proof'. Where tenants do not have secure tenure, it is questionable whether there are sufficient incentives for tenants to invest in improving the quality of house construction (Quan and Dyer, 2008). Also, IPCC (2014b) confirms that people without tenure security are hardly to be expected to take long-term decisions on climate issues.

In sum, adapting to and mitigating of climate change in urban areas is strongly related to land tenure, land tenure security and land use planning: an important domain of land surveyors.

### Rural areas

Agriculture is an important emitter of greenhouse gases, has the highest potential for reducing emissions through carbon stocks and is the sector that is most affected by climate change (Quan and Dyer, 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 emission, which is more than the total transport sector (13%). Deforestation, agriculture and livestock grazing are the major changes of land use, causing increase of the release of carbon into the atmosphere (31% of total human-induced GHG emissions of 49 Gtons CO<sub>2e</sub>, thus 15 Gtons CO<sub>2e</sub>). The burning of fossil fuels such as oil and coal, and land use change are the two dominant sources: fossil fuel burning counts for 27.7 tons CO<sub>2e</sub> and agriculture for 15 Gtons (non-forest agricultural land use change 6.5 Gtons plus deforestation for agriculture 8.5 Gtons).

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 sector is able to also remove greenhouse gases from the atmosphere, namely through sequestration and storage. Carbon pools are in oceans and the earth's crust, and also in tree biomass, vegetation, roots, forest litter, dead wood, and soil. Unless the carbon is locked in biomass over the long term, it will contribute to the growing greenhouse gases in the atmosphere with long-term climate consequences (Barnes and Quail, 2009). About 1600 Gtons of this terrestrial carbon (equals 5872 Gtons CO<sub>2e</sub>) is estimated to be stored in the soil as organic matter, while some 540–610 Gtons is stored in living vegetation, such as long-living forests, grasses and palms. Intergovernmental Panel on Climate Change estimates that agriculture has a sequestration potential of 4.0–4.3 Gtons CO<sub>2e</sub> a year by 2030, against a 100\$/Gton cost level (IPCC, 2007a; Scherr and Sthapitt, 2009).

What should be done? Scherr and Sthapitt (2009) summarises the options.

#### **Enriching soil carbon**

The soil, being the third largest carbon pool on earth's surface, can be managed aiming at reducing emissions by minimising tillage, reducing use of nitrogen fertilisers and preventing 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 annually 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 dairies, and the clearing of natural grasslands and forests for grazing. 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**

A total of 4bn ha of forests and 5bn ha of 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 also 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 fertilisers 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 and Sthapitt, 2009). Adaptation and mitigating climate change can be promoted by governments, but the main actors are the people having their livelihood in the rural areas. They should feel committed to measures and investments. This is especially important in the case of people possessing informal tenures and informal housing, in places where the climate challenges are great. Improving tenure security in these areas can have an impact on the desire and ability to implement climate change measures (Quan and Dyer, 2008). Also IPCC (2014b) confirms that tenure security is one of the factors, which are key to enhancing farmer's adaptive capacity, which is directly related to the vulnerability

because of the breakdown of traditional land tenure systems, and the risk to women households because of tenure insecurity.

In sum, climate proof rural land management can significantly contribute to climate change adaptation and mitigation. In addition, enjoying secure land tenure might be a prerequisite for people investing in climate proof land use. Both, land use management and land tenure are within the domain of land surveyors.

#### **Forest areas**

As said before, 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 13m ha each year. Latin America and Africa have suffered the largest net loss of forests, estimated at 4.3m and 4.0m ha annually, respectively, from 2000 to 2005 (FAO, 2005). This loss represents an emission of 4 Gtons CO<sub>2</sub>e annually.

But the potential to remove GHG is great (photosynthesis process), namely 13.8 Gtons a year by 2030, against a 100\$/Gtons cost level (Scherr and Sthapitt, 2009). In particular, carbon stock in live biomass is capable of removing greenhouse gases from the atmosphere. To cope with deforestation in general, many countries attempt to pursue a forest policy that restricts legal logging and combats illegal logging, such as in South Africa, Uganda, Nicaragua, Surinam, and Brasil (FAO, 2010).

The UN-programme to reduce greenhouse gas emissions from deforestation and forest degradation (REDD and REDD+) aims at planting 4m ha of forests annually, to partly compensate the 13m ha that are cleared every year. Ownership rights of land and of the sequestered carbon stock, along with the management and control of REDD+ projects, are the most critical elements to be accounted for in REDD+ projects (Quan and Dyer, 2008). Protecting the tenure security of vulnerable forest peoples is 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 are the cause of the widespread deforestation. This is caused by uncontrolled logging and conversion of forest land to other use (Quan and Dyer, 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) and future benefits of REDD+ for poor people require therefore attention to tenure issues (IPCC, 2014a).

In particular, the tenure situation of forest dwellers appears to be of influence whether deforestation occurs and whether forestation can be successful: the domain of land surveyors.

#### **Coastal areas**

A total of 634m people (10% of the world's population) are estimated to live in the low elevation coastal zone

(the coast less than 10 m above sea level), 360m of whom live 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 to the pressure of urbanisation, problems of inadequate land use planning and in addition the lack of secure tenure (Quan and Dyer, 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. These regions will require improved systems for land use planning, flood risk management, drainage, and coastal protection. But also to improve access to land for resettlement and to facilitate both planned and spontaneous migration including temporary and permanent displacement as a result of high flood events (Quan and Dyer, 2008; Correa, 2011).

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

The main land policy implication (in coastal areas) is intensified resettlement planning and a stronger role for the government in land use planning for areas at risk and areas available for resettlement. This requires investments in a land inventory and in 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 and Dyer, 2008).

In sum, land tenure and resettlement processes are part of the solution in coastal areas, which are part of the domain of the land surveyor.

### Conclusion of this part of the paper

This section aims at demonstrating 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 each of them 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. In both urban, rural, forest and coastal areas, key elements relevant for land surveyors are 'land management' and 'land administration'.

### About the Kyoto Protocol and carbon markets

When a certain carbon offset has been realised, the Kyoto Protocol allows for a trading mechanism. The reason to address the carbon market in this paper is a debate whether a carbon credit is a property right, which – if so – currently

lacks security of tenure. A separate question is whether the market anyhow works: the current overcapacity appears to be a serious problem. The authors end with a conclusion for this section.

### Compliance market

Articles 6, 12 and 17 of the Kyoto Protocol establish a market for the trading of 'assigned emission units' (AAUs). This is known as the 'compliance market', structured to facilitate the trade in emission rights. Article 17 allows countries that have 'AAUs' 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. When 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 his 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 markets, however, on a voluntary basis (Barnes and Quail, 2009). The value in 2011 of the global market amounted to \$176bn, representing an emission volume of 10 Gtons of CO<sub>2e</sub> (World Bank, 2012).

Also the greenhouse sinks (carbon sequestration and storage in soils and vegetation) can be used by countries to fulfil their obligation to reduce greenhouse gases. Articles 3.3 and 3.4 of the Kyoto Protocol provide for such measure.

### Voluntary markets

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 in the form of 'voluntary emission reduction units (VERs)'; critically, the voluntary market is still unregulated in that it has no market standards (Harris, 2007).

The value of the voluntary market in 2012 amounted up to \$523m representing 101 Mtons of CO<sub>2e</sub> (Peters-Stanley and Yin, 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 materialise the potential of carbon sinks include also reforestation, grazing land management, cropland management, and re-vegetation.

## Is carbon credit property?

Whether an emission right 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 (ACCUs) are financial products and no property rights. If the marketing of carbon credits however requires a 'title for a carbon sink', then one should consider those rights as separate from the property title for the land (e.g. 'unbundling of property rights') (Wallace and Williamson, 2006a, 2006b).

To date, it is recognised that transactions in voluntary carbon credits such as traded 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 characterises 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 also the House of Commons (HoC, 2007).

Indeed, fraud has been a big continuing problem with emissions trading. EU already lost US\$5bn 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 and Quail (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 what 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 and Quail, 2011).

Key words from the carbon markets for our professional domain are 'security of carbon credit rights', 'secure carbon transactions' and 'appropriate recording'.

## Problems in the carbon credit market

Currently, the price for carbon in the ETS has collapsed, on one hand because of reduced industrial demand, on the other hand because of the 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 raised whether carbon trading is the proper solution to climate change indeed (REDD Monitor, 2013). The popular press present clear opinions, such as 'Replace Kyoto with global carbon tax', as the Guardian (12 March 2009) says; 'Forget Kyoto: putting a tax on carbon consumption', claims Environment 360 (6 November 2012). Also, IPCC (2014b) writes that pricing carbon emission (both by taxation and cap-and-trade) can achieve mitigation in a cost-effective way, but also concludes that so far these measures are implemented with diverse effect, because of 'national circumstances'. The latter implicitly refers to the failure of the European ETS: the far too generous granting of allowances and occurrence of fraud brought it almost to a collapse, making Andrew (2008) conclude 'The EU ETS should be a warning to all'. In addition, also scientific publications give evidence that currently a carbon tax is the most effective means of reducing emissions such as Hsu (2011), who evaluates four options namely carbon tax, command-and-control regulation, cap-and-trade, and government subsidies and convincingly concludes in favour of carbon taxation.

## Conclusion of this section

The unique characteristic that land and forestry can also remove greenhouse gases from the atmosphere makes proper land use management to reduce emissions and generate tradable carbon credits, both in the cap-and-trade system and in the voluntary market. Especially in the voluntary market literature analyses security problems both in ownership and in transactions. If a carbon credit is indeed a 'stick in the bundle of rights' (which – so far – is under debate), a cadastre might contribute to enhanced carbon tenure security. When a carbon market is no solution, but carbon taxation is, appropriate tax administration will be required.

## The interference of climate change with the land surveyor's domain

Although some authors (in the past) were pessimistic for the future of land surveying (Mahoney *et al.*, 2007), others believe global developments now present significant opportunities for the profession (Fairlie, 2009; Enemark, 2009). This might fuel the discussion on making surveying education more relevant (Mattsson and Vaskovich, 2010; Young *et al.*, 2011). The profession of a land surveyor as defined by FIG (1991) and meanwhile updated in 2004 (FIG, 2004,) will therefore change. Based on a critical analysis of Coutts (2012), the definition is again in process for an update (Coutts, 2013). This paper refers to this development, addressing the interference of land surveyors and climate change.

The key elements for the land surveyor's profession found in the first part of the paper concern (1) the inclusion of climate aspects in urban-, rural-, forest-, and coastal zone land management and (2) land administration for security of land tenure and – possibly – carbon credits.

## The key element of land management

Land surveyors involved in land policy advice can extend their competence with climate change measures. Where are we talking about? Concerning *urban* areas,

the reduction of urban emissions can (at least partly) be met when policy choices include three sorts of measures. The *first* is to work on 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. The *second* is the appropriate design of urban spaces, so that mixed land use is possible, better orientation of buildings is achieved to capture solar energy and improve sunlight availability. *Third*, is the aspect of modern building design that includes low carbon running costs. In this way, 'low carbon cities' can be achieved. Just two examples are the successful energy saving policy in four Italian cities as described by Zanon and Verones (2013) and the explicit role of land surveyors in the energy transformation in Germany by Friesecke (2014).

When it comes to *rural and forests* areas, policy choices are required on how to increase soil carbon storage, how to restore of degraded lands, how to apply cultivation methods that improve carbon sequestration (such as more rice cultivation, livestock and manure management) and how to increase of forest covered area. For example, Harper *et al.* (2007) reports about improved land management in Western Australia comprising reforestation of previously cleared farmland, destocking rangelands and conversion from conventional to no-till cropping. Another example is the positive effect of land consolidation on the reduction of nutrient loads in water (Hiironen and Niukkanen, 2013). A sample of farmers in Panama and Brazil adopted organic agricultural production including no-till and achieved equal yield and 90% less soil erosion, reports (Scherr and Sthapitt, 2009). Yet another example is the Conservation Reserve Program in Colorado, where private owners are guided to convert highly erodible crops to other uses as described by Failay and Dilling (2009).

The main land policy implication in *coastal* areas is intensified resettlement planning and a stronger role for the state in land use planning for areas at risk and for the availability of land for resettlement, to achieve disaster resilience. Quan and Dyer (2008) shows the importance of land in providing alternative accommodation and flood shelters in the case of Bangladesh. Kaidzu (2014) reports how land surveyors in Japan arrange the reconstruction of cadastral boundaries after the earth quake of 2011 for the restoration of property and the resettlement of owners of lost lands.

In particular, land tenure and land tenure security need substantial policy backing. Formal property rights, informal land rights, and the way how they are protected cannot work without policy decisions. IPCC (2014a) confirms that property rights need to be strengthened, by developing institutions that define property rights and land tenure security, also when it regards community property rights.

Land surveyors involved in land management can adopt climate change measures in land use planning and implementation. Where are we talking about? The Kyoto Protocol requires societies to respond to climate change by reducing greenhouse gas emissions and coping with the changes. The IPCC synthesis reports of 2007 and 2014 summarise various options, such as reduction of transport needs, energy-efficient houses and commercial buildings through the establishment of

energy labelling and building codes. Regarding adaptation measures, the reports suggest various measures such as 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. By consequence, various sectors in society have a role in finding solutions for climate change (for instance, the transportation sector, housing sector, and the agricultural sector), and the coordinating mechanism for this is spatial planning (land use planning), especially at the local level (Biesbroek *et al.*, 2009). Land surveyors who are qualified to address climate change aspects, can contribute to the integration of these different interests. In addition, geospatial information makes integration of these interests possible. Roughly indicated as 'spatially enabled societies', land surveyors can contribute extensively in dealing with a variety of data sources and integration techniques. Examples are the generation of maps identifying opportunities for energy reduction and greenhouse gas emission in urban areas, based on integrated cadastral data, planning data and environmental data (Vranken and Broekhof, 2012), or the experiments in USA demonstrating the benefit of geo-information to identify patterns of carbon sink dynamics, based on integrated remote sensing data and ground inventories as reported by Geospatial World May 2011. Other examples are the development of a heat-loss map in Alberta (Canada) and the solar atlas of Berlin (Navarra, 2012), and the use of sensor webs for smart cities (Reichardt, 2015).

#### *The key element of land administration*

Land surveyors typically are involved in land information systems, notably cadastres. With this in mind, sustainable land administration systems should be designed and maintained also to underpin climate change adaptation and mitigation and the prevention and management of natural disasters (Enemark, 2012). This means that, in addition to the appropriate registration of land tenure and cadastral geometry, information is required about – for example – the environmental rating of buildings, energy use, current and potential land use related to carbon stock potential and greenhouse gases emissions, clear 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, salinisation 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. An example of a carbon cadastral system is the data model given by Barnes and Quail (2009). The underlying concept of complex land market commodities such as carbon credits can be found in the study by Wallace and Williamson, (2006a, 2006b).

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. An adequate tax administration system is a prerequisite in case governments decide to levy such carbon tax.

When governments want to award good carbon stewardship, also then a system is needed. Guidelines on REDD (Reducing emissions from deforestation and forest degradation), REDD+ and VCM (Voluntary Carbon Market), provide limited requirements on how project beneficiaries should be identified and how relevant property rights are to be recorded. Based on an analysis of seven projects, Mitchell and Zevenbergen (2011) concludes that this gap can be bridged by land administration systems, which provide mechanisms for project boundary demarcation, cadastral and participatory mapping, mapping of social tenure and overlapping rights, and recording of certificates, preferably recognising and recording both *de jure* and *de facto* rights to land and resources. This is confirmed by Unruh (2008), who found that, because of the disconnect between statutory and customary tenure systems, serious obstacles occur for forestation projects in Africa.

Land administration systems also have to fulfil 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 when commercial parties are in demand of land for purposes of large-scale biofuel production or afforestation for carbon sequestration. But also to provide information about tenure, value and use of land when governments want to encourage changes in for example livestock and crop production, encourage conversion from arable land to grazing land and from till to no-till cropping, or to pursue reforestation. The pressure to develop such innovative land administration system is manifest (Augustinus, 2009). Examples are the development of marine cadastres (Sutherland and Nicols, 2006; Ng'ang'a *et al.*, 2004), 3D cadastres (Stoter, 2004), point cadastres as in Guinea Bissau (Hackman-Antwi *et al.*, 2013) and the flexible and extensible land administration and social tenure domain model by Lemmen (2012a). Quan and Dyer (2008) reports about the Tanzania Village Land Act (1999), and Mozambique Land Act (1997), aiming at improving the security of community based resource management. Further examples are the land certification process in Ethiopia (Deininger, 2008), the titling project in Rwanda (Lemmen and Haarsma, 2012b), the registration of communal lands using aerial photography in Namibia (Meijs, 2009) or alternatively with unmanned aerial systems (Volkman, 2014), and the potential of registration of dynamic land rights for pastoralists in Kenya (Lengoiboni, 2011). In addition, land surveyors can give attention to the influence of climate change on cadastral boundaries. Stapleton (2010) provides examples of such boundaries affected by drought, sea level rise, and natural disaster.

When governments need lands to realise 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. Recognition of existing rights and their eligibility for compensation in case of eminent domain implies recording *de jure* and *de facto* rights. This is a matter of fairness, or good governance (equity) or even human rights (Pentassuglia, 2010). It is at the heart of local adaptation to changing climate risks, (Satterthwaite *et al.*, 2007) observes. It is – by the way – good to realise that reality sometimes shows that even an official property title is not a safeguard against eviction, depending on the political context and the coercive powers of others (Bromley, 2008), so titling in itself is not a silver bullet.

Land surveyors involved in land administration, can thus 'make a difference' when creating land administration systems, which meet the mentioned climate change demands.

## General 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 underpinning land administration systems. The production of compliance and voluntary carbon credits with the goal of managing greenhouse gas emissions, facing legal security problems, might require the active engagement of land surveyors in both carbon assessment (Bird *et al.*, 2010) and recording. This depends on whether carbon credits are considered as a property right. The involvement of the 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 in the design, development and maintenance of appropriate supportive land administration systems. The tools are there (Lemmen, 2012a; Zevenbergen *et al.*, 2013; FIG/World Bank, 2014). The implication on the qualifications of the surveyor is a further development from the legal and technical aspects of boundary surveying in the past, towards a highly multidisciplinary level of societal demand and professional support in the (near) future.

## References

- Andrew, B. 2008. Market failure, government failure and externalities in climate change mitigation: the case for a carbon tax. *Journal for Public Administration and Development*, 28, pp.393–401.
- Augustinus, C. 2009. Improving access to land and shelter. *World Bank/FIG Land & Poverty Conference*, Washington DC, USA.
- Barnes, G. and Quail, S. 2009. Property rights to carbon in the context of climate change. *Proceedings WB Land and Poverty Conference*, Washington, DC.
- Barnes, G. and Quail, S. 2011. Land tenure challenges in managing carbon property rights to mitigate climate change. *Land Tenure Journal*, 2, pp.2–11.
- Biesbroek, G. R., Swart, R. J. and van der Knaap, W. G. M. 2009. The mitigation-adaptation dichotomy and the role of spatial planning. *Habitat International*, 33(3), pp.230–7.
- Bird, N., Pena, N., Schwager, H. and Zanchi, G. 2010. *Review of existing methods for carbon accounting*. CIFOR Occasional paper 54. Bogor, Indonesia.
- Bromley, D. W. 2008. Formalizing property relations in the developing world: the wrong prescription for the wrong malady. *Land Use Policy*, 26, pp.20–7.
- Correa, E. 2011. *Populations at risk of disaster: a resettlement guide*. Washington, DC: World Bank, [with F Ramirez, and H. Sanahuja].

- Coutts, B. J. 2012. Towards 2020-critical developments in land surveying in 60 years. *Proceedings Working Week International Federation of Surveyors FIG*, Rome, Italy.
- Coutts, B. J. 2013. Redefining the profession of land surveying. *Working Week International Federation of Surveyors FIG*, Abuja, Nigeria.
- Deininger, K., Ayalew, D. and Holden, S. 2008. *Rural Land Certification in Ethiopia*. World Development, 36(11).
- Enemark, S. 2009. Facing the global agenda. *Proceedings Working Week International Federation of Surveyors FIG*, Eilat, Israel.
- Enemark, S. 2012. Sustainable land governance: three key demand. *Proceedings Working Week International Federation of Surveyors FIG*, Eilat, Israel.
- Failay, E. and Dilling, E. 2009. Carbon stewardship: land management decisions and the potential for carbon sequestration in Colorado, USA. *Environmental Research Letters*, 5, pp.1–7.
- Fairlie, K. 2009. Navigating the global consciousness. *Proceedings Working Week International Federation of Surveyors FIG*, Eilat, Israel.
- FAO. 2005. *The state of the world's forests*. Rome, Italy: FAO.
- FAO. 2010. *Developing effective forest policy*. Rome, Italy: FAO.
- FIG. 1991. *Definition of a surveyor*. Copenhagen, Denmark: FIG. [FIG Publication No. 2].
- FIG. 2004. *Definition of the functions of a surveyor*. Decision General Assembly, 23 May, Athens, Greece. p.40.
- FIG. 2010. *Spatial planning in coastal regions: facing the challenge of climate change*. Copenhagen, Denmark: FIG. [FIG Publication No. 55].
- FIG/World Bank. 2014. *Fit-for-purpose land administration*. Copenhagen, Denmark: FIG. [Publication Nr. 60].
- Friesicke, F. 2014. Transforming the energy system in Germany: about the role of the surveyor in dealing with climate change. *Proceedings Congress International Federation of Surveyors FIG Kuala Lumpur Malaysia*.
- Hackman-Antwi, R., Bennett, R. M., de Vries, W. T., Lemmen, C. H. J. and Meijer, C. 2013. The point cadastre requirement revisited. *Survey Review*, 45(331), pp.239–47.
- Harper, R. J., Beck, A. C., Ritson, P., Hill, M. J., Mitchell, C. D., Barrett, D. J., Smettem, K. R. J. and Mann, S. S. 2007. The potential of greenhouse sinks to underwrite improved land management. *Ecological Engineering*, 29, pp.329–41.
- Harris, E. 2007. *The voluntary carbon offsets market*. IIED Markets for Environmental Services Number 10, 2007, London, UK.
- Hiironen, J. and Niukkanen, K. 2013. Possibilities to reduce nutrient loads to water systems in land consolidations. *Proceedings Working Week International Federation of Surveyors FIG*, Abuja, Nigeria.
- HoC. 2007. *The voluntary carbon offset market*. Report HC331, London, UK.
- Hsu, S. -L. 2011. *The case for carbon tax: getting past our hang-ups to effective climate policy*. Washington, DC: Island Press.
- IPCC. 2000. *Land use, land use change and forestry*. Geneva, Switzerland.
- IPCC. 2007a. *Working group 3*. Geneva, Switzerland.
- IPCC. 2007b. *4th synthesis report 2007*. Geneva, Switzerland.
- IPCC. 2014a. *Working group 2: climate change 2014: impacts, adaptation and vulnerability*. Geneva, Switzerland.
- IPCC. 2014b. *5th synthesis report 2014*. Geneva, Switzerland.
- Kaidzu, M. 2014. Land Management Issue Related to Recovery from East Japan Earthquake. *Proceedings Congress International Federation of Surveyors FIG Kuala Lumpur Malaysia*.
- Lemmen, C. H. F. and Haarsma, D. 2012b. Rwanda brings 10 million parcels under registered title (interview with Emmanuel Nkurunziza, director general Rwanda National Resource Authority). *GIM International*, 26, p.6.
- Lemmen, C. H. F. 2012a. *The land administration domain model*. PhD. University Delft, the Netherlands.
- Lengoiboni, M. 2011. *Pastoralists seasonal land rights in land administration*. PhD Dissertation. Wageningen University the Netherlands.
- Mahoney, R., Plimmer, F., Hannah, J. and Kavanagh, J. 2007. Where are we heading? The crisis in surveying education and a changing profession. *Proceedings Working Week International Federation of Surveyors FIG*.
- Marrakech Accords. 2001. *Chapter J Decisions 7/CP.4 and 14/CP.4*. UNFCC Marrakech Morocco.
- Mattsson, H. and Vaskovich, M. 2010. Capacity building in land management. *Proceedings Working Week International Federation of Surveyors FIG*, Sydney, Australia.
- Meijs, M. C. J., Kapitango, D. and Witmer, R. 2009. *Land registration using aerial photographs in Namibia: costs and lessons*. World Bank/International Federation of Surveyors FIG Land and Poverty Conference, Washington DC, USA.
- Mitchell, D. and Zevenbergen, J. A. 2011. Towards land administration systems to support climate change mitigation payments. *Land Tenure Journal*, 2, pp.2–11.
- Navarra, D. and van der Molen, P. 2012. *Urban Governance and Climate Change*. GIM International November 2012.
- Ng'ang'a, S. M., Sutherland, M., Cockburn, S. and Nicols, S. 2004. Towards a 3D marine cadastre in support of good ocean governance. *Computer Environment and Urban Systems*, 28, pp.443–70.
- Pentassuglia, G. 2010. Indigenous groups and the development of jurisprudence of the African Commission on Human Rights. *Human Rights Review 2010-3*, London UK.
- Peters-Stanley, M. and Yin, D. 2013. *Maneuvering the Mosaic; state of the voluntary carbon markets*. Forest Trends' Ecosystems Marketplace and Bloomberg New Energy Finance.
- Quan, J. and Dyer, N. 2008. *Climate change and land tenure*. IIED/FAO Land Tenure Working Paper No 2. London UK/Rome Italy.
- REDD Monitor. 2013. *Carbon trading not the solution to climate change*. Washington, DC: REDD Monitor Publication.
- Reichardt, M. 2015. *Smart cities and sensor webs*. Noida: Geospatial World.
- Satterthwaite, D., Huq, S., Pelling, M., Reid, H. and Lankao, P. R. 2007. *Adapting to climate change in Urban Areas: the possibility and constraints in low- and middle-income nations*. London: IIED.
- Scherr, S. J. and Staphitt, S. 2009. *Mitigating climate change through food and land use*. Worldwatch Report 179, Washington DC, USA.
- Stapleton, M. 2010. Climate Change and the Cadastral Surveyor. *Proceedings Congress International Federation of Surveyors FIG Sydney Australia*.
- Stoter, J. 2004. *3D cadastres*. PhD dissertation. Delft University. The Netherlands.
- Sutherland, M. and Nicols, S. 2006. Issues in the governance of marines spaces. *FIG International Federation of Surveyor. 2006. Administering Marine Spaces: International Issues*, FIG Publication 36, Munich, Germany.
- UN Habitat. 2010. *Land, environment and climate change*. Nairobi, Kenya: UN Habitat.
- Unruh, J. D. 2008. *Carbon Sequestration in Africa: the land tenure problem*. *Global Environmental Change*, 18(2008).
- Volkman, W and Barnes, G. 2014. Virtual Surveying: mapping and modelling cadastral boundaries using unmanned aerial systems. *Proceedings Congress International Federation of Surveyors FIG Kuala Lumpur Malaysia*.
- Vranken, M. and Broekhof, S. 2012. Contribution of cadastral information to climate change policy in the Netherlands. *Proceedings Working Week International Federation of Surveyors FIG*, Rome, Italy.
- Wallace, J. and Williamson, I. P. 2006a. Building land markets. *Land Use Policy*, 23(2), pp.123–35.
- Wallace, J. and Williamson, I. P. 2006b. Developing cadastres to service complex property markets. *Computer Environment and Urban Systems*, 30(5), p.2006.
- Wamsler, C., Brink, E. and Rivera, C. 2013. Planning for climate change in urban areas. *Journal of Cleaner Production*, 50, pp.68–81.
- World Bank. 2012. *State and trends of the carbon market*. Washington, DC: World Bank.
- Young, G., Smith, M. and Murphy, R. 2011. Making surveying education relevant. *Proceedings Working Week International Federation of Surveyors FIG*.
- Zanon, B. and Verones, S. 2013. Climate change, urban energy and planning practices. *Land Use Policy*, 32, pp.343–55.
- Zevenbergen, J., Augustinus, C., Antonio, D. and Bennett, R. 2013. Pro-poor land administration: principles for recording the land rights of the underrepresented. *Land Use Policy*, 13, pp.595–604.