Cadastres and Climate Change

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

SUMMARY

This paper explores the role of land registers and cadastre in supporting measures that aim at adapting to and mitigating climate change. To that end, the paper provides a brief introduction to climate change in general. The paper then continues by analyzing the role of housing, land use, land-use change and forestry with respect to carbon storage and emission reduction. It appears that –in certain cases such as a FAO/IIED report on large-scale biofuel production)– land tenure and land management are of eminent importance. The paper also refers to the evolving voluntary retail market for carbon credits, which even might constitute a 'title' in their own right and be registered separately from an ownership title. To promote carbon sequestration and emission reduction, land policy and associated land instruments such as market regulation, land use planning, land taxation and land reform should include climate-proof goals. To facilitate good land policy and its implementation, the paper encourages land registers and cadastres to extend their traditional purposes of markets and taxation to include contributing to adaptation to and mitigation of climate change.

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1. INTRODUCTION

As climate change affects the livelihoods of people on earth, it is most likely that land and houses will play a role in adapting to and mitigating climate change. This paper first aims to use desk research to identify the role of land and houses. Then, the elements of such adaptation and mitigation are explored, to identify the role of land owners, land users and land managers (using policy reports and scientific literature). Finally, based on the author's earlier papers (see www.oicrf.org), some explorative research is pursued to identify the role of land registers and cadastres in adapting to and mitigating climate change. As far as the author is aware, this area still represents a wide gap in our knowledge.

2. CLIMATE CHANGE IN GENERAL

The regular Synthesis Reports of the Intergovernmental Panel on Climate Change (IPCC) provide observations and analyses concerning (a) changes in climate regardless of their causes, (b) an assessment of such causes and (c) a projection of future climate change.

The latest report (2007) states that the fact that the climate system is warming is 'unequivocal: as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and the rising of the global average sea level'. As a rough estimate, this could result in more precipitation in the north, more droughts in the south, fewer cold days, more hot days, heat waves and higher sea levels. As a secondary effect, the IPCC expects many natural systems to be affected, such as glacial lakes, early spring events, bird migration, and shifts in plant and animal species towards the polar regions, salinity and earlier greening of vegetation. Various scenarios show the impact on human systems such as crop productivity, coastal zones, flood plains, health, industry and settlements prone to extreme weather events and drought.

More specifically, Africa is expected to be exposed to increased water stress, reduced rain-fed agriculture, affected low-lying coastal areas and diminished access to food. Asia is expected to suffer from decreased availability of fresh water, higher risk for delta areas and pressure on natural resources. Europe is expected to be faced with floods and erosion, glacier retreat, reduced availability of water, worse weather conditions in the south, and increased health risks because of heat waves and wildfires. The Americas are expected to be prone to gradual replacement of tropical forests by savannah, loss of biodiversity, decreased livestock and crop production, less precipitation, heat waves in the north and increased rain-fed agriculture. Cereal productivity is expected to increase at mid and high latitudes and to decrease in lower latitudes, which has a negative impact on food security and the livelihoods of small farmers and fisheries.

The drivers for climate change appear to be both natural and anthropogenic. One example of a natural driver is solar radiation. Anthropogenic drivers include greenhouse gas emissions from human activities. The IPCC reports that the global increase of carbon dioxide (CO2) is due to fossil fuel use and changes in land use. Global increases in methane levels (CH4) are very likely due to agriculture and fossil fuel combustion. The increase in nitrous oxide (N2O) is primarily due to agriculture.

A special report published by the IPCC (2000) discusses how different land use and forestry activities affect carbon stocks and greenhouse gas emissions. Carbon is retained in live biomass, in organic matter and in the soil. When human interventions lead to changes in live biomass, land use and forestry, the carbon stock also changes, which in turn influences the global carbon cycle. For example, the report reveals that substantial amounts of carbon have been released when forests were cleared. Greenhouse gas emissions occur as a result of restoration of wetlands, biomass burning and fossil fuel combustion, intensive tillage, fertilization of lands and forests, rice cultivation and enteric fermentation.

3. KYOTO PROTOCOL

In Article 3.1 of the Kyoto Protocol, parties agreed to limit and reduce their greenhouse gas emissions between 2008 and 2012. Furthermore, countries that signed the Protocol can use afforestation, reforestation and deforestation as potential contributors to the reduction of emissions (Article 3.3). The same counts explicitly for measures regarding land use, land-use change and forestry (Article 3.7). This aspect is where we find the link to discuss the role of cadastres in climate change, as managing lands and forests requires an active land policy, instruments to implement such policy, and land tools to facilitate government intervention in private and public rights to land and housing.

4. ROLE OF LAND USE, LAND-USE CHANGE AND LAND MANAGEMENT

The UN Food and Agriculture Organization (FAO) states in its publication ‘Climate Change and Food Production’ (2008) that sustainable agricultural production plays a role in adapting to and mitigating the impact of climate change, because (a) agriculture 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. FAO is well aware that expanding biofuel production is likely to lead to greater competition for access to land. This requires sound land tenure policies and land-use planning; otherwise, the livelihood of farmers, pastoralists, fishermen and forest dwellers without formal land tenure rights will be at risk. Greater land tenure security is conditional to applying various mitigation and adaptation measures.

A study by the International Institute for Environment and Development (IIED, 2008) elaborates the relation between the two, revealing that accelerating expansion of bio-ethanol and bio-diesel production might offer opportunities for small-scale farmers by revitalizing land use in rural areas and increasing both yields and incomes. However, both would depend on land tenure security. Large-scale biofuel production also might provide employment, skills

development and secondary industry, creating potential for long-term poverty reduction. To achieve such results, the IIED advises establishing land policy frameworks that give clearer definitions of concepts of idle, under-utilized, barren, unproductive, degraded, abandoned and marginal lands, in order to avoid land allocation to large-scale biofuel industries to the disadvantage of local livelihoods. Existing land tenure patterns should be recognized and implemented within a broader circumstance of taxation, subsidies, markets and trade.

Research (e.g. Rothamsted, 2005) demonstrates that sound land management results in lower greenhouse gas emissions from all links in the food chain, provides carbon sequestration in soil and vegetation, and replaces fossil fuels with renewable bio-energy crops. Pfister et al. (2004) discuss the relations between climate change, land-use change and run-off predictions in the Rhine and Meuse river basins. The research concerns the influence that changes in land use had on the hydrological subsystem, which interacts with the climate system. They found that 'in general field drainage, wetland loss and urbanization result in more rapid downstream transmission of flood waves and less floodplain storage'. There was no evidence that land-use changes affected flood frequency and flood magnitude. Whether changes in the hydrology of the Rhine and Meuse were more strongly influenced by climate change than by land-use change appeared to be difficult to say.

Similarly, Juckem et al. (2008) investigate the effect of land-use change in the 'driftless area' in Wisconsin. Although increased precipitation was significantly higher than in other watershed areas, they argue that the changes were likely linked to changes in the soil properties as a result of agricultural land management practices.

Research by Eve et al. (2002) explains the background behind removing CO2 from the climate by growing plants which are able to store organic carbon in the soil. The paper shows that 'under the US Conservation Reserve Program about 13 million hectares of highly erodable croplands were taken out of agricultural production by converting them, by planting it back to grass or trees. Because then the soil is not disturbed and biomass is not removed: the soils have shown an increase in carbon storage. Also, adopting reduced tillage resulted in increased soil carbon storage because the soil is less disturbed, even more for no-till-at-all land use'.

Fertilization by using organic manure also enhances carbon storage in the soil, because of both the carbon content of the manure and the increase in biomass production. Eve's paper concludes that 'there is a net effect of land use and management changes on agricultural lands resulting in an increase of soil carbon storage'.

Cowie et al. (2007) sees potential synergies between existing multilateral environmental agreements and the implementation of land-use change and land management to adapt to and mitigate climate change. The basic idea is that land-use change and land management can be used to increase the terrestrial carbon pool, which at the same time contributes to the Biodiversity Convention (CBD) and the Desertification Convention (UNCCD). Measures taken into account in this study include 'conversion from conventional cropping to reduced tillage, manure, rotation, irrigation, biocrops, plantation, new forests, which appear to impact

on both less emissions of greenhouse gases, biodiversity and desertification and reforestation.' The paper concludes that 'good land management is necessary, in order to manage forests, cropping and grazing systems, biofuel production and that –when land managers continue to respond to current market demands– the environmental externalities are not acknowledged.'

The land tenure problem regarding carbon sequestration becomes manifest in Unruh (2008/9). This research shows that 'the possibility of sequestering large quantities of atmospheric carbon through woody biomass increment via tree planting projects in the tropics…has impressive potential'. However, afforestation and reforestation projects have to be initiated by governments that have often little to say in areas outside the urban sphere, because the Western notion of property rights and land law are often limited to those particular parts of the country. In remote and rural areas, customary land management prevails and is overruled by statutory land tenure arrangements. Unruh argues that there are five main obstacles for such projects, namely '(1) the land tenure disconnect between customary and statutory land rights, (2) legal pluralism, (3) tree planting as land claim, (4) the functioning of treed area expansion in smallholder land-use systems and (5) the abandoned land problem.' Tree planting projects require 'improved governance, which assumes single land law for the entire population', through which the land rights of customary land holders can be guaranteed. Literature reveals that this is hardly a realistic way forward, as governments often neglect the land rights of customary peoples and the poor often 'need to be protected against the government…' Furthermore, tree planting in Africa often 'signifies a land claim', so that tree planting projects are perceived by local communities as unfair and unjustified land claims by the government, which are perceived to be conflicting with their own land rights. Unruh asks, 'given the land tenure obstacles to the afforestation and reforestation approach, will it be possible to realize sequestration goals within the time whereby the impact will be meaningful?'

Harper et al. (2007) investigates the potential of greenhouse sinks to underwrite improved land management in Western Australia. The problem is that Australia is faced with 'salinization of land and water resources, recurrent wind and water erosion of both cultivated agricultural lands and rangeland, and the prospect of continued climate change due to increases in the concentration of greenhouse gases in the atmosphere.' There might be 'opportunities for the land management sector arising from greenhouse gas abatement and in particular the development of carbon sinks as a result of land use change.' The carbon storage can be used to fulfill the Kyoto obligations and opens opportunities for trading in emission reductions. The research investigates the possibilities of 'carbon farming' by planting trees and shrubs on (private) farmland and de-stocking rangeland.

Carbon farming requires a title, which is made possible under the Australian Carbon Right 2003 legislation, establishing a 'title for the carbon in a sink, separate from that of the land, which provides a legal base for ownership and trading.' These carbon credit titles are treated like property titles, so they also need to be registered. Measures to materialize the potential of carbon sinks include 'reforestation, grazing land management, cropland management, and re-vegetation.'

5. ROLE OF HOUSES AND SPATIAL PLANNING

According to (IPCC 2007) the largest growth in greenhouse gases emissions between 1970 and 2004 has come from energy supply, transport and industry. In addition to the 'land sector' (section 4), the urban environment therefore also needs attention. 'About 30-40% of the total energy consumption in western countries is assigned to building. About 50% of these refer to the energy consumption for indoor air conditioning (heating and cooling)' (Pulselli et al, 2009). Regarding the effects of climate change on the built environment (Roberts, 2008) clarifies that buildings play an important role in both adaptation and mitigation. 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. (Hamza et al, 2009) reports about the role of building regulations in the UK, which originally were introduced to safeguard public health and safety, but now -after revision- are seen as a tool for 'limiting the environmental impact of the built environment on natural resources'. Regarding adaptation to the effects of climate change, the construction buildings that are resistant to weather extremes like flooding and storms, require not only new construction methods, but also a land use planning that allocates building construction at the right location (Roberts, 2008). Recognizing the role of various sectors in society for finding solutions for climate change, like the transportation sector, housing sector, agricultural sector, the coordinating mechanism still is the spatial planning especially at local level (Biesbroek et al, 2008). That explains the role of local governments (or 'sub-national governments'), as they have control over 'areas that crucially affect greenhouse emissions, such as transportation, energy use, land use regulation and environmental education' (Puppim, 2008). 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). In order to monitor the energy use, several countries introduced environmental rating of buildings. As more than 80% of energy used in households is dedicated to space heating, large savings are expected to be gained in the housing stock. Sweden investigates an external and an internal factor (Malmqvist et al, 2009), while Denmark, Belgium, the Netherlands, Germany publish so called energy labels, in order to create awareness amongst the populace concerning energy use of houses and potential savings. That energy labeling is not a immediate success, reveals an investigation in Denmark, where no significant energy saving where found despite this was the main goal of the Danish Energy Labelling Scheme (Kjærby, 2008) and an investigation by a national real estate agent association (VBO) in the Netherlands, that revealed that only 38% of house buyers paid attention as whether an energy label was available for the property they were interested in (Dutch News, 30 January 2009).

6. MITIGATION OF AND ADAPTATION TO CLIMATE CHANGE

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 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, land management 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. Regarding adaptation measures, the report suggests e.g. 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.

Concerning the underlying policy framework, the report refers to institutional reform, land tenure and land reform, capacity building, integrated land-use planning, building codes, and national water policies.

7. CARBON CREDITS MARKET

Articles 3.3 and 3.4 of the Kyoto Protocol provide for the use of greenhouse sinks (carbon sequestration in soils and vegetation) to be used by countries to fulfill their obligation to reduce greenhouse gases. Articles 6, 12 and 17 establish a market for trading assigned emission credits. This is known as the 'compliance market', structured to facilitate the trade in emission rights, based on cooperation with developing countries in carbon sequestration projects ('Clean Development Mechanism'). Article 17 allows countries that have 'assigned emission units' to spare to sell their surplus credits to countries that are over their targets. Since carbon dioxide is the principal greenhouse gas, people speak simply of 'trading carbon' (UFCCC website, accessed 30-9-2008).

The Dutch government, for example, under the Clean Development Mechanism (CDM) of the Kyoto Protocol and the EU Emission Trading Scheme (EU-ETS), has a portfolio of 28 projects in 11 different countries, consisting of various energy technologies such as wind power production, methane gas recovery and biofuel production; the total contracted volume is 17.4 million tons of carbon dioxide equivalent (SenterNovem website, accessed 7-11-2008). The government even created a supervisory authority for emissions trading: the Dutch Emissions Authority (NEA).

Apart from the compliance market, a 'retail offset market has also 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; critically, the voluntary market is still unregulated in that it has no market standard' (Harris, 2007).

Here we observe the creation of a new commodity, in line with the research on land markets (Wallace et al., 2006a, 2006b), where she describes that land markets increasingly include more complex commodities. In the carbon credit case, this concerns a 'new commodity in the form of emission reductions or removals'.

This leads to opportunities for such measures as carbon farming (Harper et al., 2007), to generate tradable carbon credits through –in the Australian case– 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. In this situation, marketing carbon credits requires a title for a carbon sink, which is separate from the property title for the land ('unbundling of property rights'), which also might require registration.

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'. It is remarkable that 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, while existing land administration system could so easily adopt such carbon credit rights in their registers.

8. ROLE OF LAND POLICY, LAND INSTRUMENTS AND LAND TOOLS.

Adaptation to and mitigation of climate change, by their very nature, challenge professionals in the fields of land use, land management, land reform, land tenure and land administration to incorporate climate change issues into their land policies, land policy instruments and facilitating land tools. This is similarly applicable to water and coastal zone professionals. It is clear that land registers and cadastres in themselves cannot induce mitigation and adaptation of climate change. However, they must serve as a sound information base for the implementation of land management policies.

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

In the case of 'unbundled' property rights, with the separation of carbon credit titles, these registers and cadastres should be able to register such rights (registration) and to attach appropriate geometric attributes (see section 10) and to make those titles accessible for trade in the carbon credit market. Land registers and cadastres 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 in case of e.g. demands for land for purposes of large-scale biofuel production or afforestation for carbon

sequestration and 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 such objectives, land registers and cadastres are supposed to provide relevant information about taxable objects, taxable values and taxable persons, including earlier mentioned indicators regarding energy use etc.

When governments need lands to realize certain land use (water storage, carbon sinks), land registers and cadastres 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. When land reform is at stake, land registers and cadastres provide information about the existing land tenure pattern and provide an operational process to change from old to new situations. In summary, land registers and cadastres have a role to play in supporting governments and citizens in their efforts at mitigating climate change and trying to adapt to its impact.

9. THE CASE OF THE DUTCH KADASTER

As one of the signatory parties to the Kyoto Protocol, the Netherlands' government recognizes the urgency and scale of the global climate challenge: its goal is a 30% reduction in greenhouse gas emissions by 2020, relative to the benchmark year of 1990, preferably as part of a European effort. In view of the fact that 50% of the land area in the Netherlands is located below sea level, it is no surprise that coping with the rising average seawater level, the higher run-off and discharge predictions for the major rivers and extreme precipitation forecasts is a priority.

However, the government realizes that measures to cope with water management should be coupled to measures on land use, nature conservation, urbanization, transport and recreation. Therefore, the National Adaptation Policy is based on the concept of integrated land-use planning, which combines objectives of sustainable coastal defense measures, supplemented by robust river water systems, sustainable cities, climate-proof buildings and climate-proof agriculture.

Since January 1, 2008, legislation has entered into effect that requires an energy label to be available at the time of transactions related to the construction, sale or letting of houses. The energy label issued for a specific house provides information about the energy consumed during its standardized use. These energy labels form a new category in the land registers. To date, the Netherlands' Cadastre, Land Registry and Mapping Agency, known as Kadaster, has registered about 50,000 labels. The energy labels are open for public inspection, as is all cadastral data.

Kadaster supports the government in providing not only all information about land tenure, value and use of land and houses, but also about public properties and environmental limitations regarding use, noise, soil pollution, nuisance. It also supports land acquisition by the government in order to implement anti-flooding measures.

The land consolidation expertise available at Kadaster is put into practice when the government aims at realizing better climate-proof agricultural business structures as well as sub-catchments for river water. As a consequence of sea level rise, seawater will also penetrate further into the estuaries of the Rhine and Meuse, causing salt intrusion leading to high salt concentrations. In this area as well, Kadaster provides relevant land information to support land-based anti-salinization spatial planning.

10. JOB OPPORTUNITIES FOR LAND SURVEYORS?

A study by the IPPC (2000) reveals widespread demand for a well-designed carbon accounting system that provides for the 'transparent, consistent, comparable, complete, accurate, verifiable and efficient recording and reporting of changes in carbon stocks and/or changes in greenhouse gas emissions by resources and removals by sinks from applicable land use, land use change and forestry activities'. Although different approaches are possible, in many cases land surface areas, above-ground and below-ground volumes of biomass, canopy surveys, and geoinformation play a role. The Greenhouse Office of the Australian Department of Environment publishes its Full Carbon Accounting Model on the web (Full CAM, assessed 13-11-2008) and also provides what is known as a 'National Carbon Accounting Toolbox and Data Viewer' to allow land managers to ensure that their projects or regional emissions accounts are determined on a similar basis to Australia's official recording of emissions from the land sector.

The methods used for calculating carbon credits demonstrate a remarkable similarity to the work of quantity surveyors, whose profession it is to survey land areas and volumes to estimate building and construction costs. To date, the author is unaware of any publications which explore the possible extension of the surveying profession towards the quantification and qualification of carbon credits and emission reduction rights.

11. CONCLUSIONS

Land registers and cadastres have to extend their function beyond the conventional use for land markets and land taxation. The data comprised in the land information systems are also useful to facilitate government policy on adapting to and mitigating climate change. Registering new rights in the form of carbon credit titles would be feasible. With all these aspects in mind, the idealistic concept of registers and cadastres as 'multi-purpose' land administration systems becomes a real possibility.

REFERENCES

Biesbroek, G.R., Swart, R.J., van der Knaap, W.G.M., 2008, The mitigation-adaptation dichotomy and the role of spatial planning, Habitat International xxx (2008) in press, *Elsevier Science.*

Cotula, L., Dyer, N., Vermeulen, S., 2008, Bio-energy and Land Tenure, IIED/FAO Land Tenure Technical Papers No 2 (May 2008).

Cowie, A., Schneider, U.A., Montanarella, L., 2007, Potential synergies between existing multilateral environmental agreements in the implementation of land use, land change and forestry activities, Environmental Science and Policy 10 (2007) 335-352, *Elsevier Science*.

Eve, M.D., Sperow, M., Paustian, K., Follett, R., 2002, National-scale estimation of changes in soil carbon stocks on agricultural lands, Environmental Pollution, 116 (2002) 431-438, *Elsevier Science.*

Grazi, F., van den Bergh, J.C.J.M., 2008, Spatial organization, transport, and climate change, Ecological Economics 67 (2008) 630-639, *Elsevier Science.*

Harper, R.J., Beck, A.C., Ritson, P., Hill, M.J., Mitchell, C.D., Barrett, D.J., Smettem, K.R.J., Mann, S.S., 2007, The potential of greenhouse sinks to underwrite improved land management, Ecological Engineering 29 (2007) 329-341, *Elsevier Science*.

Harris, E., 2007, The Voluntary Carbon Offsets Market, IIED Markets for Environmental Services Number 10, 2007, London UK.

Huq, S., Reid, H., Murray, L.A., 2006, Climate Change and Development Links, IIED gatekeeper Series 123, IIED London.

Intergovernmental Panel on Climate Change IPCC, 2007, Synthesis Report 2007.

Juckem, P.F., Hunt, R.J., Anderson, M., Robertson, D.M., Effects of climate and land management change on stream flow in the driftless area of Wisconsin, Journal of Hydrology (2008) 335, 123-130, *Elsevier Science*.

Netherlands Ministry Housing, Spatial Planning and the Environment, 2007, Maak ruimte voor klimaat ('Make space for climate'): national adaptation strategy, an intra-governmental policy memo, The Hague NL.

Pfister, L., Kwadijk, J., Musy, A., Bronstert, A., Hoffmann, L., 2004, Climate Change, Land Use Change and Runoff Prediction in the Rhine-Meuse Basins, River Research and Applications 20 (2004) 229-241, *John Wiley & Sons.*

Pulselli, R.M., Simonchi, E., Marchettini, N., Energy and Energy based cost-benefit evaluation of building envelopes, Building and Environment 44 (2009) 920-928 *Elsevier Science.*

Puppim de Oliveira, J.A., 2008, The Implementation of climate change related policies at sub-national level, Habitat International xxx (2008), in press, *Elsevier Science.*

Roberts, S., 2008, Effects of climate change on the built environment, Energy Policy 36 (2008) 4552-4557, *Elsevier Science.*

UNFCCC, 1998, Kyoto Protocol (entered into force 2005) website www.unfccc.int

Unruh, J.D., 2008/9, Carbon Sequestration in Africa: the land tenure problem, Global Environmental Change, in press, *Elsevier Science.*

Wallace, J and **Williamson** I.P., 2006a, Building Land Markets, *Land Use Policy Vol. 23, Issue 2 April 2006*.

Wallace, J, and **Williamson,** I.P., 2006b, Developing Cadastres to service complex property markets, *Computer Environment and Urban Systems, Vol. 30 issue 5 September 2006*.

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