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Low carbon land development: Is there a future for integration across sectors?

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A B S T R A C T

The Copenhagen Summit of the UNFCCC Conference of Parties may have disappointed enthusiasts for a predictable future for the Kyoto Protocol. But it did mark a turning point in climate change negotiations' search for tools and mechanisms within sectors and at scales not given sufficient attention before. Today national and sub-national levels of carbon and offset trading schemes covering many land use and natural resources development sectors are emerging. They provide more opportunities to integrate ecosystem and people's benefits and create a more balanced link between climate change and sustainable development futures. The time for establishing a pioneering world network of low carbon development zones (lcdzs) for experimenting and learning from spatial

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integration of efforts across land use sectors is now. Its realization would however require hitherto unforeseen levels of cooperation within the UN and among its Member States.

Contents

1. Introduction

Low carbon development is a commitment of all nation states; efforts to meet that commitment are fragmented across a number of sectors that contribute to growth. Impacts of these efforts on the future of "business as usual" development trajectories remain difficult to measure or predict. Expectations that catastrophic scenarios forecasted for the coming decades of this new century could trigger a worldwide shift away from fossil fuels have not come true. Continued fossil fuel use is inevitable for many nations aspiring for economic prosperity. Even developed, industrialized economies that have the technological know-how to aim for rapid shifts into renewable energy continue to justify dependence on fossil fuels based on security, geopolitical and economic considerations. For the foreseeable future, development will continue to be a mix of energy-intensive and energy-secure economic growth running parallel to tinkering for improving energy efficiencies and minimizing green-house-gas (GHG) emissions in as many other sectors as possible.

A sector specific focus on low carbon development is likely to continue because most expertise and knowledge for low carbon development are sector- or sub-sector specific. For example, renewable energy expertise on wind, solar, hydro and geothermal options are separate at the practitioner level. Integration of knowledge across these different sub-sectors to assess the overall potentials at a meta-, renewable energy sector-level is often undertaken by regional and global think tanks. However, incentivizing cooperation between sub-sector operations within jurisdictional and administrative geographies remains a challenge. Difficulties and constraints to integration multiply when agency actors who coordinate sectors are distinct even though their practices and actions, such as that of forestry and agriculture, or public transport and residential buildings lie juxtaposed to one another in landscapes.

In this paper we call for greater encouragement to and support for land and terrestrial ecosystems to promote low carbon development. Low carbon land development combines mitigation measures against GHG emissions with collateral benefits to ecosystem health and human wellbeing. Until now, decisions on tradeoffs, either between emission reductions of different GHGs or emissions of different sectors or sub-sectors for priority support and investment had been based largely on global opportunities and market potential. Identifying sectors and mitigation measures that can generate multiple benefits and diminishing tradeoffs within coherent planning and governance contexts at

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sub-national and local levels is a way-forward for low carbon development. We use examples and cases that each of us have been engaged with in order to explore the potential for low-carbon development becoming an integrator of multi-sector actions in landscapes to benefit ecosystems and people. In addition, we propose the setting up of a dedicated network of places for international collaboration that can serve as low-carbon development zones (lcdzs) where integrated, multi-sector approaches could be tested and lessons learned.

2. Carbon, markets and governments

The United Nations Framework Convention on Climate Change (UNFCCC) through the adoption of the Kyoto Protocol in 1997 set off several attempts to bring governments and markets together to design, develop and execute carbon trading schemes. The European Union Emissions Trading Scheme (EU ETS), which still is the platform for the largest traded volumes of carbon-assets has unfortunately become a victim of global economic downturn that began in 2007–2008. Although traded volumes continue to grow within EU ETS, carbon unit prices have plummeted. The allowances allocated to power plants and other industrial and energy sector installations based on assumptions of boom-times of early-to-mid 2000s have resulted in a glut of credits as EU economies suffered sharp downturns since 2008. It is estimated that the EU would need an annual GDP growth of 4.3% from 2013 to cancel out the oversupply of carbon credits that is now putting downward pressure on the price of a tCO_2e within the EU ETS (World Bank, 2012b), an unlikely scenario given the near-zero growth rates in many EU economies at present.

Global attempts to prioritize fossil fuel, industry and energy sectors as prime targets for GHG mitigation have underestimated the costs of adaptation that businesses and people would have to incur. Land use and land use change could have provided greater incentives for learning through action during the past decade. An early critic of the Kyoto Protocol (Victor, 2001) argued that the Kyoto framework is based on a fundamentally wrong assumption that it is best to slow global warming by setting strict targets and timetables for regulating the quantity of GHGs emitted. He highlighted an important innovation in the Montreal Protocol, an “escape clause” that kicks in when controlling emissions becomes too costly, and suggested that Kyoto and other international law regimes learn from such pragmatism. His observation in relation to CO_2 absorbed by trees and plants is worth quoting in the context of this paper's emphasis on low carbon land development: “Forests are especially large sinks – forests are growing larger and denser in all advanced industrialized countries, in part because intensive farming is reducing the need for cropland and some of the abandoned land reverts to forests…………The more credit awarded for CO_2 that plants and trees are already absorbing, it is easier for nations to comply with the Kyoto targets without actually changing behavior.”

China and India, the world's two demographic billionaires that are leading emerging economies also registered significant recovery of forests during 2000–2005 (The Economist, 2006). In 1998, soon after the conclusion of the Kyoto Protocol in December 1997, China embarked on a National Forest Conservation Program to raise percentage of forest cover from less than 20% to 26% within a 10 year period (Mayer et al., 2005). Retrospectively, one can only imagine the directions global climate change negotiations and actions would have taken if such favorable, on-going land use changes were the starting points for negotiations instead of the difficult and costly transformations in the fossil fuel and industrial sectors.

Although Copenhagen Conference of Parties (COP) of UNFCCC is widely seen as an event which failed to ensure the effectiveness of the Kyoto Protocol beyond 2012 we agree with the authors of the report on the State and Trends of the Carbon Market (World Bank, 2012b) that it marked a “turning point in the political economy of climate change in emerging economies.” Ministries of Finance and Planning are engaging to a greater extent in global climate change negotiations than ever before searching for domestic (national and sub-national) instruments to mitigate climate change that extends beyond the industrial to forestry, agriculture and other land use sectors.

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Furthermore, Copenhagen witnessed the extension of REDD (Reducing Emissions from Deforestation and Degradation of Forests) to REDD+ emphasizing conservation, improved forest management (IFM) and enhancement of forest carbon stocks. UNFCCC took the REDD proposal further in COP 19 in Warsaw, Poland in 2013 to establish a framework for financing REDD+ together with biodiversity and other services provided by forests beyond carbon sequestration. The World Bank has identified several investment funds focusing on land use carbon (see Annex 2, Table 14 of World Bank (2012b)) and all of them, except 2 of the World Bank based funds were launched in 2011 or later. Sylvain Goupille, Managing Partner and Chief Executive of Althelia Ecosphere, the owner of largest of such funds (Althelia Climate Fund) has noted: "*In this transition period for climate finance, it is essential to identify how financial resources can be efficiently deployed and to offer innovative solutions to support the development of nested REDD+ projects. Althelia is committed to bring its expertise and capital, and act today to define pathways to successful and efficient implementation of climate finance (see*: http://www.ecospherecapital.com/our-vision/)."

3. Reducing GHG emissions: ecosystem specific cases, examples and opportunities

3.1. The rainforest

During 2009–2012, the Brazilian Plant Inteligencia Ambiental and Florestal Santa Maria (Manfrinato et al., 2012) successfully established a VCS (Verified Carbon Standard) certified project for a 71,714 ha rainforest patch in the southern parts of the Amazon. It is the largest forest management initiative registered within the Brazilian State of Matto Grosso and is embedded in a 400,000 ha area where deforestation and forest degradation drivers advanced unabated during 1995–2012 (Fig. 1). A net saving of 29,923,331 tCO_2e for the period up to 2030 is foreseen. Of this amount, 22,340,000 tCO_2e of emissions have been verified as tradable VCUs (Verifiable Certified Units).

Global corporations such as the Bunge Emissions Group, the climate market division of the food and agribusiness company Bunge, and the Santander Bank Group have engaged in purchasing VCUs directly from the land owner. They have committed to purchase several tranches of VCUs; and the placement of VCUs with others seeking to offset their emissions nationally and globally is underway. New innovative schemes of neutralizing urban transportation emissions nationally have evolved using VCUs generated by this project. Given that 57% of the largest companies in Brazil have their own voluntary reduction plans and 60% of the voluntary carbon credits from the whole of Latin America originate in Brazil (World Bank, 2012b) prospects for finding additional buyers for VCUs generated by the project are promising. The action by the Bunge Group, in particular may be seen in the context of a commitment of the Global Consumer Group Forum made ahead of the Rio+20 Summit in June 2012 to ensure that commodity production of its members will be deforestation-free by 2020 (Ishwaran, 2012).

The project's achievements to-date has been a tough challenge. For long, sustainable logging has been a low priority to land owners due to the relatively advantageous cost/benefit equations of alternative, non-forest economic activities which drive deforestation. In 2008 many carbon-offset buyers started to view IFM projects favorably because of its potential not only to lessen climate change but also generate social and environmental benefits for communities (EcoSecurities, 2009). As REDD+ received global encouragement following Copenhagen landowners have a better economic rationale to invest in IFM operations that include non-timber products as outputs, with significant ecological and social benefits-sharing at the regional level. IFM also has clear opportunities to introduce changes to conventional forestry to improve biodiversity benefits. More than 60% of Sabah's 11,000 orangutan population lives in forests that have been exploited several times and continue to produce timber (Ancrenaz et al., 2005). REDD+ projects can provide the incentives to extend logging cycles if forestry incomes can be diversified to include payments for carbon sequestration and other ecosystem services over and above timber production.

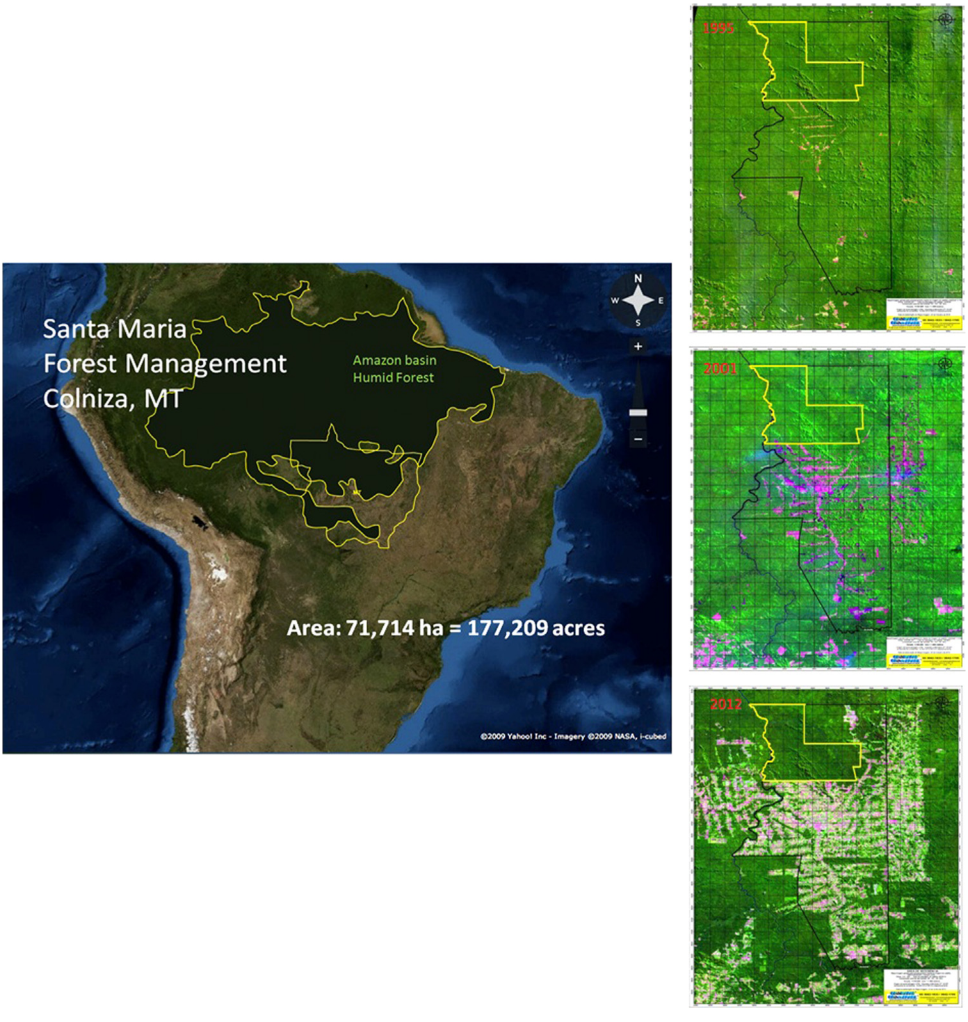

Fig. 1. Satellite images for 1995, 2001 and 2012 used in estimating deforestation rates and deriving tradable VCUs for the experimental area in Matto Grosso, Brazil.

3.2. Agro-ecosystems

In 2011 sustainable agricultural land management (SALM) entered the voluntary carbon market arena (Ecosystem Market Place, 2012). Reduced nitrogen fertilizer use through biological N fixation was approved for CDM (Clean Development Mechanism of the Kyoto Protocol) by UNFCCC in 2009. In the California carbon market, launched in 2012, avoiding emissions from agriculture is acceptable for carbon trading; and methodologies for carbon offsets from reduced use of N fertilizers for crop production have been developed and approved (see http://www.arcadiabio.com/news/press-release/un-clean-development-mechanism-approves-arcadia-biosciences-methodology-links and http://americancarbonregistry.org/acr-approves-msu-epri-methodology-for-emissions-reductions-from-agricultural-n2o/view).

Agriculture contributes only 13% to global GHG emissions (IPCC, 2007). But, N_2O and CH_4, which are 298 and 26 times more potent than a unit of CO_2 respectively, in driving global warming, constitute significant parts of agricultural emissions. Although more than 50% of people in the world now live in urban areas, total volume of emissions from the sector will rise as less-developed countries, dependent on agricultural commodities for income generation and employment grow economically. Reducing excessive use of fertilizers can reduce N_2O emissions and also increase farm incomes; in the Shanxi Province of China a 50% reduction in fertilizer use has been associated with a 4–15% increase in household incomes (Norse et al., 2011; Norse, 2012).

The potential for simultaneously improving agricultural productivity and mitigating GHG emissions calls for an in-depth exploration of greater application of biochar (Woolf et al., 2010). Field experiments across several sites for different crops, soil categories, and environmental conditions have been conducted in China (Liu et al., 2012, in press). Results show crop productivity increases of 5–25% and carbon emission reductions of 25–45% under biochar soil amendment of 20–40 t/ha. These results were sustained over a 2–3 year period (Liu et al., in press). Biochar reduces the need for fertilizers and avoids associated N_2O emissions. Other studies across a wide range of conditions have demonstrated that biochar could serve as a slow-releasing compound fertilizer (Joseph et al., 2013; Qian et al., in press), metal immobilizer/stabilizer (Bian et al., 2013) and soil quality improver and amender for salt-stressed soils (Lashari et al., 2013; Zhang et al., 2012). In China, biochar products have been developed from crop straw and other agricultural residues for applications in energy production, fertilizer industry, crop yield improvements and land treatment. Abatement rates, measured in tCO_2e per hectare per year was found to be highest for biochar among 20 different land management practices in Africa, Asia and Latin America (World Bank, 2012a). In China, linking biochar's climate change mitigation benefits to carbon offsetting within the domestic voluntary trading system is being explored.

Results of these trials justify wider socio-ecological experimentation on the use of biochar for sustainable development benefiting economy, environment and society in rural areas. Open-air burning of agricultural and forestry residues can increase GHG emissions. Controlled burning of the same using pyrolysis techniques can produce biochar, as well as syngas that can be used for community level power generation. Collection and transport of farming and forestry residues to a distributed network of biochar and syngas production facilities and their re-distribution and supply back to farming communities is a business opportunity in rural economies of less developed countries that merits in-depth financial feasibility studies (Pan et al., 2011; http://www.scientificamerican.com/article/can-straw-provide-chinas-energy-needs/).

Agricultural expansion and conversion to pastureland together with destructive logging, fires and infrastructure development may account for as much as 20% of global GHG emissions (see http://www,un-redd.org.aboutredd/tabid/102614/default.aspx). Crop expansion is also a major threat to biodiversity (Phalan et al., 2013). The future of sustainable low carbon development must therefore address the challenge of increasing agricultural productivity per unit land area if it is to realize the potential for land set asides for agro-forestry and forestry as well as for land use promoting environmental and biodiversity priorities. Opportunities for converting degraded lands to productive agricultural lands can also minimize pressure for new lands for cultivation. The German Agency for Technical Cooperation (GIZ) in China (www.giz.de/china) has launched a land use carbon project using pilot sites for (i) restoration from coal mining impacts, (ii) sustainable timber production and (iii) agricultural practices to reduce nitrogen fertilizer use.

3.3. *Urban, sub-urban and rural ecosystems*

As places of concentrated residential and commercial buildings, private and public transport systems and energy supply units, the world's cities and their surrounding regions make up a significant portion of the 66% of global emissions attributed to these sectors (IPCC, 2007). As hubs of economic and financial activity introducing abrupt changes to city infrastructure and lifestyles for favoring low carbon footprints is not easy. Strict emission and energy efficiency targets may not gain acceptance even on an experimental basis if risks and costs to income generation and standard of living outweigh benefits in the short-to-medium term.

Significant and potentially low cost reductions of carbon emissions are feasible when precinct scale of action is the focus for de-carbonizing the economy. But, municipalities often lack the carbon assessment tools to estimate GHG emissions and energy production and consumption patterns, assess their impacts, assist with decision-making and deliver low carbon strategies and outcomes. The C^{CAP} Precinct Tool developed by the company Kinesis in Australia moved beyond ratings and checklists and serves as a planning and design tool for assessing environmental, economic and social indicators within urban areas. Based on intelligent in-built assumptions and GIS mapping software, the tool enables measurements of carbon emissions in energy and water usage, land use, transport and materials embodied in development (Beattie et al., 2012). Melbourne University's 'MUtopia' and the Green Building Council's 'Communities' tools are other emerging, potential alternatives. However, these tools are expensive and are not made public; use of the tools requires data, information and funds which may be beyond the reach of precinct level authorities (Bunning et al., 2013).

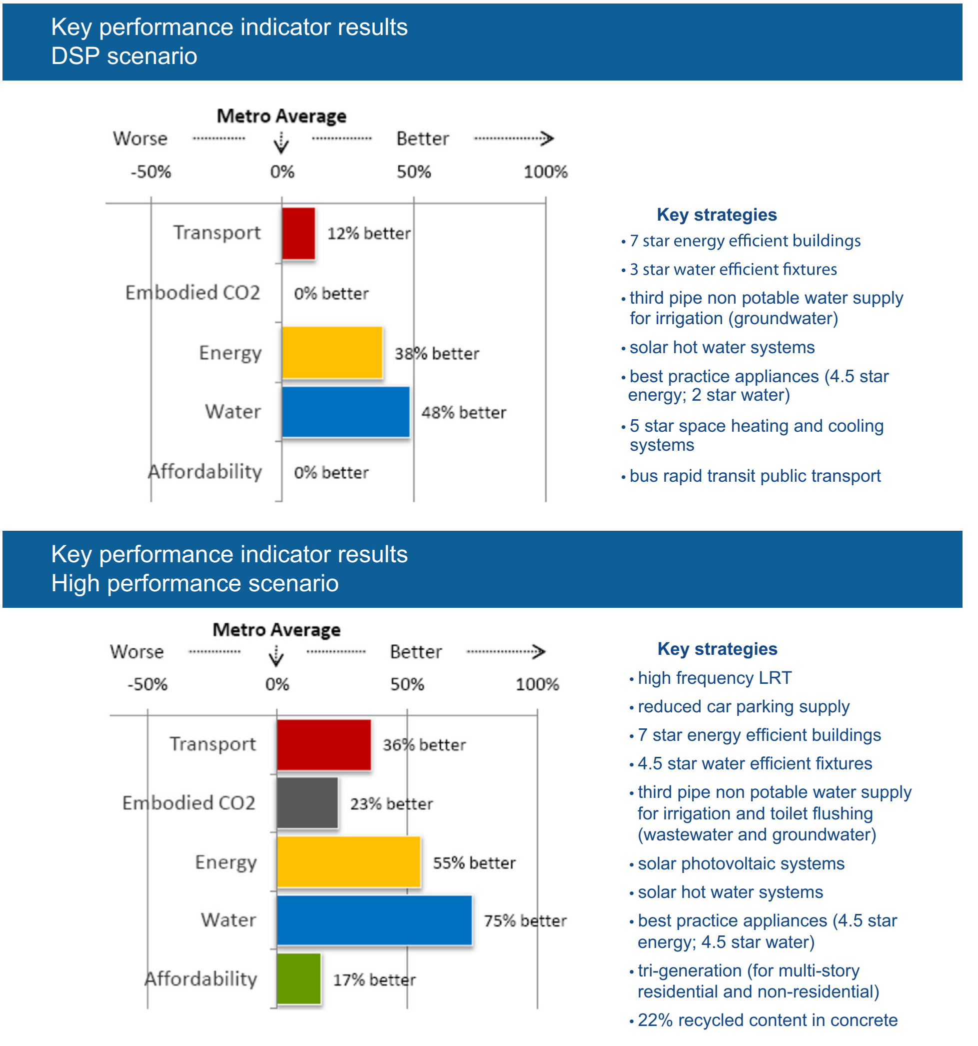

Fig. 2. Comparison of Key Performance Indicators (KPIs) for the District Structure Plan (DSP) and High Performance (HP) cases for Cockburn Coast Development, Western Australia. LRT in the high performance scenario refers to Light Rail Transport

Kinesis' C^{CAP} Precinct modeling tool has been used to evaluate numerous key performance indicators (KPI) on sustainability. Comparing a development proposal with a business-as-usual model, the tool offers a host of metrics that demonstrate how specific technologies and policies will impact each KPI (Bunning et al., 2013). Fig. 2 represents the District Structure Plan (DSP) case and a high-performance case, and their strategic components for the Cockburn Coast Development in Western Australia. Although the high performance case was 17% more affordable than the DSP case it also carries a high risk of implementation. Investor needs for safe returns and/or low risks may compel decision makers to settle for the DSP case while committing to specific improvements that can trend towards the high-performance scenario over time. DSP scenario as it stands does achieve considerable improvements in energy, transport and water sectors. Due its low risk of implementation it may attract support of many stakeholders as a starting point for system-level improvements in the future.

Provinces, precincts and cities and their ecological catchments are often a mix of urban–rural populations and landscapes. Urbanization is driven by the flow of rural populations particularly the youth. Reversing that flow requires improvements to many rural development parameters. Integrated rural-urbanization, a scheme driven by one of China's largest food production and distribution company, CHIC (see http://www.chicgroup.cn/news50.php) aims to reverse the prospects for economies and quality of life in rural areas (UNESCO, 2012) by minimizing rural–urban gaps in: educational and employment opportunities; income generation and economic productivity; collaboration with universities and the scientific community for improving productivity per land unit cultivated; public service amenities and infrastructure; and social security, land ownership, tenure and governance. CHIC's first pilot site in Banan, is the most rural of the 19 districts of Chonqing municipality and has the highest density of the farming population. Chonqing municipality has an estimated population of 28,846,200 with 6-to-7 million in the urban zone. High ecological footprints of cities results from their drawing in of resources from surrounding landscapes (Wackernagel and Rees, 1996). Linking cities to low carbon development of a broader region including rural areas can counterbalance such ecological overshoot of cities. Chonqing is one of the 5 cities (others being Beijing, Tianjin, Guangzhou and Chengdu) for the pilot phase of carbon-market development in China. Possibilities for intra-district, multi-sectoral carbon offsets and trading, between urbanized and rural areas of Chonqing and other Chinese pilot cities is worthy of exploration.

4. Low carbon development: international cooperation and networking

In the North Devon Biosphere Reserve, UK, an integrated emission reduction strategy is aiming to create a “zero carbon” region through a mix of energy efficiency and conservation measures within residential and industrial sectors. On the residential front, many homes are in a state of “fuel poverty”; a high proportion of the household income is spent on energy and heating to the point that residents often need to make a choice between paying for energy or food. The Biosphere Reserve's Partnership Board is working with the government and private sector to address thermal insulation efficiency and alternative heating systems. In rural areas use of wood as fuel for heating may increase because alternative choices are poor; at the same time woodland cover will be increased and sustainable woodland management will benefit biodiversity and ecosystem services such as flood attenuation. Currently the majority of energy is produced and bought from power companies outside of the region costing an estimated UK£60 million per year for the residential sector alone; the total spent on energy for all sectors in the area is in the order of £300 million (Bell et al., 2013). A recently proposed off-shore windmill license on the edge of the marine section of the Biosphere Reserve offers not only significant renewable energy production but also opportunities for new skills development that could boost the region's intellectual and technical capacity for applying renewable energy systems more broadly. Another strand of the emission reduction strategy aims to reduce nitrous oxide by working with agricultural businesses to carefully monitor the application of artificial and organic fertilizers. The Partnership seeks local solutions for energy efficiency and agricultural yield improvements that reduce GHG emissions and aims to influence external drivers of the region’s economy so as to render cost–benefit equations favorable to the region.

Many biosphere reserves have been experimenting with carbon offset schemes; Sierra Gorda in Mexico (see http://www.worldlandtrust.org/eco-services/project-areas/sierra-gorda, for one of the many organizations working with this Reserve) is quite well known for its community based initiatives. In Giam Siak Kecil Bukit-Batu Biosphere Reserve of Indonesia the largest Indonesian business conglomerate, SINARMAS, voluntarily surrendered its right to log parts of the area to gain the status of a management partner of the Reserve. Two East African Biosphere Reserves, namely East Usambara Mountains (Tanzania) and Malindi-Watamu (Kenya) have been recently subjected to pre-feasibility studies to explore their potential for low carbon development, including for REDD+ investment. The investigations highlighted a myriad of ways by which carbon savings can be made ranging from fuel efficient stoves, sustainable forest management, agro-forestry measures, alternative livelihoods and land-use change. Land ownership, occupancy and rights of populations in and around the Reserves are very diverse and often undefined. This can make formal accounting procedures currently required by global carbon accounting standards prohibitively expensive to design and implement. However if it is done within local and/or national standards it could help in formal recording of property and traditional rights and resource needs of the local communities across gender, tribe and family. Biosphere reserves operate at a large landscape or ecosystem scale and therefore carbon reduction strategies require a multi-stranded approach and could benefit from registering and reporting against multiple methodologies.

UNESCO's World Network counts 621 biosphere reserves in 117 countries (http://www.unesco.org/mab). By design, each reserve includes a legally protected core and multiple use buffer and transition zones. As places of mixed natural and human impacted ecosystems they provide many opportunities for experimenting with low carbon land development. Aiming for "zero-carbon" status at landscape, region or at a level of defined administrative territory gives a greater range of options for

Dinghushan BR(1979)	Zhaoqin city(Dinghu)
Core Zone(ha):625.1 Buffer Area(ha):350.3 Transition Zone(ha) 158	Population (2003 est.) 150,000 Area (km²) 506 Density (/km²) 296

Fig. 3. Examples of Chinese Biosphere Reserves shown in a map of the CBRN whose transition zones overlap with third tier cities of China and the satellite image and basic information for one of them, Dingushan Biosphere Reserve, and the nearby city of Zhaoqin (Dinghu).

Table 1
Examples of carbon mitigating actions at UNESCO World Heritage Cities (WHC) and Biosphere Reserves (BRs).

	UNESCO site	Country	Region	Carbon mitigating action	Governance (implementing agency)	Financial mechanism	Community acceptance/ market penetration
1	Carcassonne, WHC	France	Europe and North America	Wind power plant (8 MW) generating renewable electricity (22 GWh p.a) for local population (100,000).	Aude department of France	French National Government	2001 French National Assembly opens up new laws for wind energy market.
				Eco-hospital (53,000 m^2) environmental design and low-energy buildings, opens 2014.	Private entity, GDF-Suez and public authorities	Public/private partnerships	Federal financial incentives for wind power deployment.
2	Cuchillas del Toa, BR	Cuba	Latin America	Passive solar and solar thermal energy used for agro-ecological management practices of Biosphere farming communities. Reforestation with precious woods	The Ministry of Science, Technology and Environment (CITMA)	National Government Local NGOs (Cuban Solar) International NGOs (German Official Collaboration Agency-GTZ) The National Forest Development Fund (FONADEF)	The National Programme for Sustainable Energy Culture is a tool for dissemination of public education on sustainability.
3	Edinburgh, WHC	Scotland	Europe and North America	Solar thermal and cutting edge insulation ('eco-decorating') of historic buildings to maximize thermal efficiency and reduce electricity consumption. Gas-engine Combined Heating Plant (CHP) planned for City districts.	City of Edinburgh Council	Green Investment Bank (GIB) £3 billion of public funding to kick-start private investment in green technologies in UK	Financial benefits for residents through feed-in-tariffs provide incentives. Promoting Community Energy Co-operatives
4	El Hierro, BR	Spain	Europe and North America	Wind-hydro station (10 MW) generating electricity for local community (11,000), tourists and Electric Vehicles.	Municipality Local ownership/co-ownership benefit sharing scheme	Private equity/ subsidies: -60% municipality -30% Spanish private company (IDAE) -10% Technological institute of Canary Islands	Public as co-owners of the Wind-hydro power station.
				Photovoltaic Panels for solar hot water			Public education campaign gained community support.
5	Hoi An, WHC	Vietnam	Asia and the Pacific	Eco-City development is a plan to become Vietnam's first eco-town and develop	UN-HABITAT (main body responsible for leadership, governance)	UNIDO	Hoi An City People's Committee promotes strategies for local

Table 1 (*continued*)

	UNESCO site	Country	Region	Carbon mitigating action	Governance (implementing agency)	Financial mechanism	Community acceptance/ market penetration
				Hoi An's green industry, infrastructure (solid waste, resource efficiency and cleaner production) and tackle environmental protection and carbon emissions, as well as strengthening urban–rural linkages.	Other UN Interventions (UNIDO, UNESCO, FAO, ILO) National Government Municipality		community ownership of projects. Participatory decision-making, inter-jurisdictional cooperation with stakeholders.
6	Kristianstad, BR	Sweden	Europe and North America	District heating with cogeneration electricity, biogas fueled buses and vehicles, waste used as fertilizer for agriculture, and wind power installed for district electricity.	Municipality	Specific municipal budget	Conflict solution with wind power and recreational and natural values involved participatory process with stakeholders to win support.
7	Ksar of Ait-Ben-Haddou, WHC	Morocco	Arab States	Solar thermal power (CSP) station (500 MW) in Ouarzazate province. First phase (160 MW).	Moroccan Government Moroccan Agency for Solar Energy (MASEN)	World Bank approved $297 million in loans to back the Moroccan Bank for construction and operation of the plant for first phase. Other foreign banks e.g. German Development Bank (KfW) commit $1.4 billion.	Moroccan national solar and wind power plan to meet country's energy deficit.
8	Mexico City, WHC	Mexico	Latin America	Car free Sunday in city Bike sharing network (EcoBici)	Municipality NGOs	Municipal government sponsorship	Services and Programs to encourage bicycle riding (free bicycle mechanic stations, medical kiosks, free bicycle loans, public theatre, yoga in park).
9	Salzburg, WHC	Austria	Europe and North America	'Smart City' design – zero energy buildings, thermal solar and district heating, production and distribution of biomass and industrial waste heat generated electricity with smart grids and use of renewables.	National Government Municipality	Federal Government – Climate and Energy Fund to support EU "Smart Energy Demo – FIT for SET" Programme	Consequent energy and Climate Protection Policy support. Renovation policy for communal buildings, Development of an "energy spatial planning" policy.

Table 1 (*continued*)

	UNESCO site	Country	Region	Carbon mitigating action	Governance (implementing agency)	Financial mechanism	Community acceptance/ market penetration
				Carbon neutral district Gningl in Schallmoos.			
10	Varna, Ancient City of Nessebar, WHC	Bulgaria	Europe and North America	Energy efficiency program for retrofitting and modernization of City's street lighting with intelligent new systems, providing significant energy savings.	European Union Municipality	Municipal bonds issued raise capital of €3 million, paid out a 9% interest, repaid over 3 years.	E-street Forum provided knowledge on new technology to owners of street lighting installations and experience of outcomes of pilot projects.

experimenting with multi-sector approaches to GHG mitigation. Place and context-specific trial-and-error efforts whose lessons and experiences can be shared internationally are integral to the work of the World Network of Biosphere Reserves (UNESCO, 2008).

Several of the biosphere reserves cover a full spectrum of ecosystems from urban through rural to the natural. In the Chinese Biosphere Reserve Network (CBRN) there are several examples; the proximity between the reserve and the nearby city is shown for one case in Fig. 3. Such third-tier cities of China hold significant promise to leap-frog into low carbon development without having to tread the conventional development options pursued by China's mega-cities. Globally, most of the urban expansion up to 2050 is expected to take place in small-to-medium sized cities of a million or fewer inhabitants (UN, 2010). A recent meta-analysis of 326 peer-reviewed case studies on urban expansion also found that half of the cases studied were within 10 km of a terrestrial protected area (Fragkias and Seto, 2012). Land use and land use change shifts within mixed natural-rural–urban landscapes, such as those found in many biosphere reserves, have important experimental and learning value for low carbon land development.

World Heritage sites (http://www.unesco.org/whc) comprise another set of UNESCO designated places that could promote networking for learning and exchange of experience in low carbon development. A recent audit of 106 World Heritage forest sites found that they are sinks for 10.6 billion tons of CO_2 (Pandey, 2012: *whc.unesco.org/uploads/activities/documents/activity-43-12.pdf*). Similar to the example in Matto Grosso of Brazil cited earlier many World Heritage sites would be suitable for the development of REDD+ initiatives. Potential examples include Rio Platano Biosphere Reserve (Honduras), the Salonga, Kahuzi Biega and Virunga National Parks (Democratic Republic of the Congo) and the Tropical Rainforest Heritage of Sumatra (Indonesia). Cultural sites include modern cities such as Brasilia and ancient ones like Angkor Wat of Cambodia; the latter is now the main driver of the tourism economy centered in the nearby city as well as the broader region of Siem Reap. There is significant potential for experimentation in low carbon development in energy efficiency, transport, water management and land use change in and around such World Heritage cities. In Table 1 a selected number of on-going or planned initiatives in World Heritage sites and biosphere reserves from energy, transportation and urban planning sectors are listed.

These "UNESCO sites" now numbering more than 1500 places in over 160 countries and covering billions hectares of terrestrial, freshwater and coastal/marine ecosystems and home to millions of people can provide an initial set of places for an international network of low carbon development zones (lcdzs) to experiment with nested approaches to climate change mitigation to generate simultaneous environmental, biodiversity, social and cultural benefits. Mature sectors such as technology, industry and finance enjoy advantages of area specific incentives in Free Trade Zones (FTZs) and exclusive economic development zones. In a similar manner lcdzs could be provided with

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incentives to attract public and private investments that can bear the increased risks associated with the promotion of new and previously untested models of development. Such area specific authority would also have the power to bring the different land use sectors to work together in order to generate concurrent ecological, economic and social benefits.

The establishment of a pioneering set of lcdzs will however require hitherto unforeseen levels of cooperation between many UN organizations and their Member States, civil society actors and the private sector. At the international level UNESCO, whose intergovernmental organs oversee the work of biosphere reserves and World Heritage sites, and UNFCCC which guides all global climate change negotiations and initiatives must pool their ideas, expertise and assets together. Implementation modalities of new UNFCCC recommended approaches to climate change mitigation, such as Program of Activities (PoAs), National Mitigation Action Plans (NAMAs) and New Market mechanisms (NMM) could significantly benefit from experimentation in lcdzs.

Projects and initiatives at individual lcdzs would require considerable coordination at national, provincial and local levels to ensure that different planning and administrative agencies overseeing the various land use sectors work together. UNDP, the UN body most present at the country level could assume an active role as an enabler of authorities given the task of such coordination in lcdzs. Civil society organizations and the private sector are likely to be attracted to contribute their expertise and resources to support such lcdzs if they are areas that enjoy international visibility and attention. The various UN agencies as well as Member States collaborating to establish the pioneering set of lcdzs may extend to those sites a “One UN” label in addition to the UNESCO label and identity that such sites already have.

Guimaraes (2006) posed the question: “is the fact that an issue brought by science has been effectively incorporated in the discourse of policy a guarantee for actual change?” The scope and nature of changes needed for mitigating climate change require actions that range from policy to practice. No amount of sound and credible policies are substitutes for trial-and-error learning through practice and creating knowledge and action modalities for low carbon futures. The creation of a set of lcdzs where legal, regulatory and financial incentives encourage bold, context specific experimentation and learning is a necessary step for climate change action at a time when the future of international regulatory frameworks remains vague. It is also an important step in strengthening networking between the global and the local as well as among public, private and civil society stakeholders which is central to the future of environmental governance (Renicke and Deng, 2000).

5. Conclusions

The Nobel Laureate Daniel Kahneman (2011) observed that: “When it comes to rare probabilities, our mind is not designed to get things quite right. For the residents of a planet that may be exposed to events no one has yet experienced, this is not good news.” Climate change and its consequences belong to the class of events that “no one has yet experienced.” Influencing nations and people to act now to avoid or minimize impacts of possible future adverse events is never going to be easy. But emphasizing climate change mitigation and adaptation experiments in places and contexts where people can test and learn changes that they can make to their own livelihoods and lifestyles is a necessary condition for improving success probabilities for the future.

We believe that there are significant advantages to redirecting climate change mitigation and adaptation to land use and land use changes rather than hoping for difficult and costly changes to be implemented in the fossil fuel sector. A recent study (Warren et al., 2013) has demonstrated that if tropical deforestation is not halted the outcome of even the strongest measures being contemplated to reduce fossil fuel emissions will be jeopardized. Increasing investment and support for a combination of avoided deforestation, IFM, SALM and integrated low carbon development at the urban–rural interface can be a significant boost for climate change mitigation and adaptation.

Learning to mitigate and adapt to climate change must be encouraged among communities and people within their own economic, social and environmental contexts. Such learning is best promoted through experimentation and action; in the words of Ivan Illich (1972): “Most people learn best by being with it.” Thinking and action to mitigate and adapt to global climate change have significant economic, social and

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political implications. As such global strategies must find local meaning and relevance that make practical sense to people and communities. The pioneering set of lcdzs chosen from UNESCO designated biosphere reserves and World Heritage sites can provide the context specific settings where climate change solutions could be tested and lessons learnt shared through international networking.

Modern environmental treaty negotiations often precede domestic public concern on the issue. Treaties such as UNFCCC and Kyoto are better tools for institutional learning rather than for solving complex issues and we will learn over time how to use such instruments to solve complex global problems (Gupta, 2001). More efforts are needed to encourage *in-situ* institutional learning for climate change and sustainable development. It could be an innovative way to implement educational and training programs and raise public awareness called for in Article 6 of the UNFCCC.

Landscapes are “bureaucratic” (Thomas, 2003). They comprise mosaics of administrative territories lying juxtaposed to each other but whose managers may dislike or even avoid working with each other. Effective climate change mitigation and adaptation must address and remedy such weaknesses in current day planning and governance frameworks if actions are to find desirable expressions in real-time land and natural resource use settings. Radical changes in the way we live, plan and manage our resources will not automatically emerge at global or even national scales through negotiations. They would have to be tried out in limited geographies and over defined periods of time and the lessons learnt translated and scaled up to spread the positive impacts. Establishing a global network of lcdzs and equipping them with necessary legal and policy incentives to encourage collaboration between international, national and local stakeholders is a necessary step in learning and preparing for low carbon futures. Internationally designated UNESCO World Heritage sites and biosphere reserves could provide the pioneering set of sample sites for such a network of lcdzs.

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