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**Article title: Co-managing carbon and air quality: pros and cons of local sustainability initiatives**

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## **Article title: Co-managing carbon and air quality: pros and cons of local sustainability initiatives**

### **ABSTRACT**

This paper reports the pros and cons of co-management (i.e. concerted actions towards climate change and air quality management) through local sustainability initiatives using three case studies, each encompassing the planning and management issues at local government levels. Case study I is policy-based and reports outcome of a consultation exercise while case studies II and III have greater scientific bearing. These case studies pave the way for development of a more integrated Climate Change Strategy Action Plan at local scales, specifically regarding policies on emissions sources from transportation and decentralised energy. They highlight the merits and the trade-offs of implementing local scale co-management practices, using a more integrated planning framework than what is currently under offer.

We recognise that delivery of such ambitious, cross-cutting agenda may be impeded, primarily owing to limited expertise in assessing the synergies and the expected outcomes from cross-fertility between these two arenas. This calls for a step-change through more cohesive, cross-disciplinary policy frameworks, going beyond the local administrative spheres to maximise the co-management potentials while mitigating the wider environmental impacts.

**Keywords:** *carbon emissions; co-management; air quality; green infrastructure; integrated assessment; local authorities*

## 1 **1. Introduction**

2 Emergence of ‘co-management’ i.e. concerted, inter-sectoral local actions towards achieving cost  
3 effective air quality improvements while managing carbon dioxide (CO<sub>2</sub>) reduction targets has gained  
4 grounds in times of austerity (Chae 2010, Thambiran and Diab 2011). Globally, there is growing  
5 emphasis on generic sub-national and national policies for maximising the returns of climate change  
6 adaptation strategies with regard to human health via improved air, water and food quality (Haines *et*  
7 *al.* 2007, Salon *et al.* 2010, Quevauviller 2011, Larsen *et al.* 2012, Takeshita 2012). The majority of  
8 ‘conventional’ air pollution as well as CO<sub>2</sub> emissions at a local level originate from anthropogenic  
9 sources, and measures to reduce one problem are likely to have some impact (either positive or  
10 negative) on the other (Hayes *et al.* 2007). National and federal governments have been increasingly  
11 empowering local authorities (LAs) to take action through localised management solutions given their  
12 wide range of responsibilities and greater understanding of underlying activities (Salon *et al.* 2010,  
13 DECC, 2012, Naiker *et al.* 2012). Owing to the lack of a formal policy ‘home’ for climate change  
14 within LAs in the UK, there has been a particularly strong set of arguments for integrating climate  
15 change strategies into aspects of well-established local air quality management (LAQM) remits. These  
16 initiatives have been broadly referred to as ‘co-management’ (Baldwin *et al.* 2009).

17

18 There have been significant calls for integrated policies, linking disparate air pollution and climate  
19 change management initiatives (van Amstel 2009, Defra 2011, EPUK 2011, UNEP 2011).  
20 Concurrently, the concept of climate change localisation and management has also been gaining  
21 centre stage (Wright *et al.* 2011). These calls are based on a range of logics. Economically, air quality  
22 co-benefits of greenhouse gas (GHG) reduction policies could potentially offset a large fraction of the  
23 cost of the mitigation actions, particularly in the developing countries (Stern *et al.* 2007, Nemet *et al.*  
24 2010). Planned actions to reduce certain air pollutants (so called ‘Short Lived Climate Forcers’) may  
25 be advantageous in slowing the rate of warming (Ravishankara *et al.* 2012), particularly in the  
26 situation where significant GHG reduction is not expected to occur in the near future.

27

28 Integrated air quality management and GHG reduction measures have been reported to offer greater  
29 benefits than those obtained from implementation of isolated measures (Chae and Park 2011). Hence,  
30 greater emphasis placed on ‘holistic’ LAQM plans and strategies, incorporating climate change  
31 considerations, or vice versa, for example see London Borough of Brent (2012). However, despite the  
32 high-level calls for joined up action on air quality and climate change, the notion of ‘co-management’  
33 has received little in-depth exploration at local scales. This is also marred by recent reports from  
34 several European countries, indicating ‘uneven adoption’ of Local Agenda 21 framework, suggesting  
35 feeble (or at least very uneven) support for the local sustainable development strategies at local  
36 governance levels across Europe (Fidélis and Pires 2009, Barrutia and Echebarria 2012). The key  
37 question remains whether significant carbon management might be better achieved utilising the same  
38 framework as applied by the LAs in the context of air quality. Theoretically, LAQM can be used to  
39 support climate change mitigation in the short-to-medium term (Thambiran and Diab 2011, Defra  
40 2011), however, the limited skill-base in LAs (developed and developing countries alike) in delivering  
41 this novel, cross-cutting agenda, augmented by the complexities in integrating local and scientific  
42 knowledge (Raymond *et al.* 2010), is likely to impede the expected outcome from improved  
43 integration of these two issues.

44

45 This paper sets out to highlight potential benefits and inherent barriers of localised co-management  
46 initiatives. It considers a number of opportunities for linking these two policy spheres – combining the  
47 management of GHG and air quality – by capturing multiple developments in the policy environment  
48 towards a single reference point of co-management. The first part of this paper presents an overview  
49 of the current practice and the issues in LAQM and carbon management approaches, highlighting  
50 their benefits and barriers within the UK context. The three case studies presented in the following  
51 section are UK specific - incorporating the varying elements of co-management, the challenges of  
52 consolidated actions and the possibilities (and the opportunities) for converging the carbon and the air  
53 quality agendas at a strategic level rather than just in terms of individual interventions. Based on these  
54 case studies the implications for an integrated strategy for co-management in the urban environment

55 (specifically regarding policies on emissions sources from transportation and decentralised energy)  
56 and the pertinent hurdles to be overcome are discussed in subsequent parts of the paper.

57

58

## 59 **2. Current issues in local scale air quality and carbon management**

60 Over the last fifteen years, LAs in the UK have been involved in rigorous assessments and  
61 declarations of Air Quality Management Areas (AQMAs) under the Local Air Quality Management  
62 (LAQM) policy framework. To date, over 230 of LAs (around 60%) have declared one or more  
63 AQMAs for different pollutants (predominantly nitrogen dioxide, NO<sub>2</sub> and particulate matter, PM<sub>10</sub>).  
64 Transportation, being a major urban activity, has been identified as the main source of pollution in the  
65 majority of the AQMAs (around 92%; Faulkner and Russell 2010), as well as being responsible for  
66 roughly 20% of UK GHG emissions (DfT 2010). This linkage has already garnered attention from  
67 academics and policy-makers with regard to their co-management potential. However, while there  
68 may be overlapping management needs, in terms of addressing the reduction in emissions at source,  
69 typically from transportation, the inherent nature of how the two entities influence the local and the  
70 wider environment would significantly affect the potential for co-management. Despite anthropogenic  
71 combustion activities being the prime source of both GHGs and air pollutants in urban settings, there  
72 is a key contextual distinction between the methodological approaches for their effective management.  
73 Air quality has a strong spatial association with residential population (expressed in legislation and  
74 guidance as exceedences of the objectives at ‘relevant locations’) and requires a management-at-  
75 source approach to avoid adverse impacts. On the other hand, GHG reduction is not reliant on  
76 location-based interventions to achieve its targets (e.g. action to reduce carbon emissions in LAs are  
77 often focussed on energy saving initiatives in relation to power plant CO<sub>2</sub> emissions that occur well  
78 outside their boundary). However, this discrepancy may be about to change if the new PM<sub>2.5</sub> exposure  
79 reduction responsibilities (EC 2008) get passed down to LAs in any way, as this will result in LAs  
80 needing to make reductions in the overall background pollution concentrations rather than just  
81 focussing on the hotspots. Further, there is also the consideration that whilst there are various end-of-  
82 pipe or combustion control technologies for many air pollutants (NO<sub>x</sub>, PM, etc.), this is not the case

83 for CO<sub>2</sub> till date, barring the proposed carbon-capture and storage technologies piloted for large coal-  
84 fired power stations.

85  
86 Devising the best approaches to achieve ‘win-wins’ (i.e. those likely to result in the reduction of  
87 pollutants of importance to air quality and climate change) from such co-management initiatives is an  
88 evolving phenomenon. The links between air quality and carbon management lie, not only in the  
89 overlaps between the sources of interest, but also in the skills and policy understandings needed for  
90 their effective management (Baldwin *et al.* 2009). Currently (2012), the policy of managing climate  
91 change through local environmental initiatives is gaining ground, and increasing amounts of  
92 mitigation and adaptation methods for climate change are being implemented at local scales (AQMRC  
93 2010). However, to facilitate this, policymakers require an understanding of the air quality  
94 ramifications of climate mitigation decisions (or at least clearly presented and plausible evidence).  
95 Whilst win-win policies are obviously most desirable, it is envisaged some actions will result in a  
96 ‘trade-off’, i.e. benefitting one aspect at the cost of the other. Over recent years some expertise  
97 involved in air quality management has been diverted towards finding a common path for providing  
98 guidance and support to LAs on the issues and the problems associated with this approach. The main  
99 area for combining carbon management with LAQM is around transportation emissions. This is due to  
100 the legacy of effective air pollution control after the 1965 Clean Air Act in the UK, which has meant  
101 that in the urban centres the vast majority of LAQM practice (at the moment) is based on  
102 transportation with very little considerations from industrial or domestic emissions. Though this may  
103 be changing due to the recent ‘dash to biomass’ with regard to ‘sustainable’ heating systems for  
104 buildings (see Case Study III below), which brings additional sources in urban/peri-urban context.

105  
106 Robust policies to co-manage climate and air quality have the potential to create significant reductions  
107 in exposure to air pollution (Ravishankara *et al.* 2012). Through the following case studies numerous  
108 opportunities, barriers and compromises are identified in order to effectively and resourcefully co-  
109 manage and mitigate CO<sub>2</sub> and LAQM pollutants while ultimately accruing cost-effective  
110 environmental benefits at LA levels.

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### **3. Case studies**

These case studies present practical and policy interactions in co-managing climate change and air quality through local initiatives, creating opportunities for positive gains for both the issues (i.e. co-benefits) as well as the inherent challenges in assessing what is beneficial for one could be deleterious for the other (i.e. trade-offs).

#### *3.1. Case Study I – Strengthening integrated policies: Reading Borough Council Air Quality and Climate Change Consultation and Action Plans*

In 2007/8 Reading Borough Council (RBC), UK conducted a public and stakeholder consultation exercise to support the coordinated development of its Air Quality Action Plan and a Climate Change Strategy for the Borough (RBC 2008). The two-phase consultation was designed to look at the interlinked issues of climate change and air quality so that areas with potential synergies and conflicts could be identified and adequately addressed (RBC 2009 [p20]). The first phase consisted of awareness raising activities - including outreach events in the local libraries, community centres, leisure centres and community group talks. The second phase was conducted in partnership with the Air Quality Management Research Centre (AQMRC) at the University of West England, UK. This consisted of a questionnaire survey and two participatory workshops. The questionnaire surveys were distributed in various ways including a stand in a local supermarket, a double-page spread in the local newspaper, through libraries and leisure centres and by post to people who had requested further contact through the postcard consultation. In total 155 questionnaires were returned and 24 people attended the workshops. Overall, local interest in environmental issues was found to be somewhat split, with local councillors more interested in engaging in a problem of global importance such as climate change, whilst citizens wanting to see more action from the local authority on the problems that are immediately at their doorstep. In response to query on the most important environmental issue 53 people identified road traffic, 39 air quality and 16 the need to mitigate climate change (Chatterton

138 *et al.* 2008). A co-management approach offered an opportunity for the LA to develop strategies and  
139 policies that meet the expectations of both their elected members and their citizens.

140

141 Following this consultation, RBC have developed a Climate Change Strategy Action Plan, joining the  
142 two separate policy streams of air quality and climate change, specifically regarding policies on  
143 emissions sources (,mainly transportation and decentralised energy) (RBC 2008). It includes 40 sets  
144 of cross-thematic objectives and actions with their estimated benefits in monetary terms. **Table 1**  
145 provides a shortlist of those objectives that cover potentials for co-management within the scope of  
146 this paper. In addition, in the council’s Air Quality Action Plan, 14 out of the 26 proposed measures  
147 have potential climate change benefits associated with them. This means that when it comes to  
148 assessing the cost-effectiveness of these measures (as required by government guidance  
149 LAQM.PG(09)) the council would be able to recognise and evaluate these additional (non-AQ)  
150 benefits. By visibly and publically making a link between the two issues, the council has helped  
151 ensure that political weight (stemming from either a desire to improve air quality or to mitigate  
152 climate change) can be put behind win-win measures through integrated policies, further increasing  
153 the likelihood of their implementation.

154

155 <place Table 1 here>

156

157 Currently (2012) there is no prescriptive legislative requirement for LAs to act on climate change  
158 mitigation; there has been a tendency for strategies to be developed at a higher, corporate level (or at  
159 least in part of the structure with a more cross-cutting remit than environmental health). The RBC  
160 joint consultation process helped to firmly link the issues in the eyes of the local managers, ensuring  
161 that whilst there are still separate Climate Change Strategy and Air Quality Action Plans, these now  
162 clearly pay reference to each other and have policies which fall across both, facilitating an  
163 overarching level of co-management.

164

165

166 3.2. Case Study II – Boosting win-wins: The All London Green Grid initiative

167 Inclusion of green infrastructure (GI) in the design, planning and management of landscape resources  
168 to conserve ecosystem functions and to provide a range of economic co-benefits to the people across  
169 Europe has seen revived trends recently (Hamdouch and Depret 2010, Llausàs and Roe, 2012). In the  
170 UK all LAs are required to have a Planning Policy Guidance (PPG17) open space strategy and  
171 accompanying dataset, though GI planning is still feeble in most cases, primarily owing to their  
172 difficulty in devising successful strategies (Defra 2012). For example, even though all the London  
173 Boroughs work within the same policy context and guidance (ODPM 2001), there is no standard  
174 protocol for classification and mapping of individual spaces. The East London Green Grid (ELGG),  
175 promoted by the Greater London Authority (GLA) as a network of multi-purpose open spaces criss-  
176 crossing the Thames basin, has accrued (or anticipated) benefits (including carbon reduction) to the  
177 tune of £4.93 to every £1 of London Development Agency investment (LDA 2011). This initiative has  
178 now been extended across London in the form of All London Green Grid (ALGG), which aims to  
179 secure a network of high quality, well designed and multifunctional green and open spaces (**Figure 1**).  
180 It has earmarked co-management opportunities in terms of ‘ALGG functions’, including adaptation to  
181 climate change, improvement of air quality and soundscapes, conservation and enhancement of  
182 biodiversity, promotion of healthy living, improve quality and access to urban fringes (GLA 2012).

183

184 <place Fig 1 here>

185

186 This case study presents the potential benefits and limitations to co-management opportunities from  
187 local scale GI planning and design strategies. It covers a section of the ALGG in the Lower Lea  
188 Valley, around the area of the City Airport and its flight paths across East London (shown with a  
189 dotted square in **Figure 1**). The estimates of CO<sub>2</sub> and PM<sub>10</sub> in the assessment have been generated  
190 using activity and emissions data from the London Atmospheric Emissions Inventory (LAEI) (GLA  
191 2010), primarily from transportation and domestic sources (**Figure 2**). The spatial configuration of the  
192 green grid network and the flight path of the City Airport are shown in greater details in the inset of  
193 this figure, with the airport runway depicted as solid black rectangle. Adequate design and vegetation

194 composition would offer co-management potentials for CO<sub>2</sub> emissions as well as wind and air quality  
195 amelioration (mainly particulate pollution) across the region, but has inherent land use challenges - for  
196 example restrictions to planting tall trees very close to the runway. From air quality perspective mixed  
197 tree cover, comprising of 75% grassland, 20% sycamore maple (*Acer pseudoplatanus L.*) and 5%  
198 Douglas fir (*Pseudotsugamenziesii*) has been shown to achieve PM<sub>10</sub> reductions in London of up to  
199 0.17 tonne ha<sup>-1</sup> yr<sup>-1</sup> (Tiwary *et al.* 2009). For CO<sub>2</sub> management on the other hand, there are different  
200 priorities in species selection; establishments of new woodlands have been shown to contribute to  
201 much higher yearly potential carbon sequestration (up to 3.63 tonne C ha<sup>-1</sup> yr<sup>-1</sup>), compared to  
202 bioenergy crops, short rotation coppice (SRC) and Miscanthus cultivation (up to 0.41 tonne C ha<sup>-1</sup> yr<sup>-1</sup>)  
203 (Cantarello *et al.* 2011).

204

205 <place Fig 2 here>

206

207 Emissions of CO<sub>2</sub> and PM<sub>10</sub> at 1 sq-km resolution for 2011, based on the LAEI are plotted along with  
208 the design of the ALGG network in the study domain (**Figures 3a and 4a respectively**). Potential co-  
209 benefits have been estimated on the basis of reported carbon sequestration (Cantarello *et al.* 2011) and  
210 PM<sub>10</sub> fluxes (Tiwary *et al.* 2009) for a mixed vegetation canopy, comprising of 75% grassland, 20%  
211 sycamore maple (*Acer pseudoplatanus L.*) and 5% Douglas fir (*Pseudotsugamenziesii*) for the 10,000  
212 ha plot. The choice of the species mix and the PM<sub>10</sub> reduction calculations applied to this assessment  
213 build on the methodology already reported in a previous study (see Tiwary *et al.* (2009) for numerical  
214 formulation and parameterisation details).

215

216 <place Fig 3 here>

217

218 The potentials for CO<sub>2</sub> sequestration is estimated in terms of annual flux to the vegetation (tonnes km<sup>-2</sup>  
219 yr<sup>-1</sup>, **Figure 3b**) whereas the air quality co-benefit is estimated as reduction in PM<sub>10</sub> concentration  
220 downwind to the plantation (at 1.5 m height about ground) (µg m<sup>-3</sup>, **Figure 4b**). The outputs support  
221 co-management potentials of the ALGG near the City Airport for both CO<sub>2</sub> and PM<sub>10</sub> reductions

222 through efficient design and choice of species, facilitating both enhanced dry deposition of pollutants  
223 on their foliage and localised carbon sinks for aircraft emissions in the region.

224

225 <place Fig 4 here>

226

227 While the pedagogical evidence generated through this case study is promising towards supporting  
228 multi-functional urban greening policies, it is still limited in scope in overcoming the inherent  
229 challenges in realising these functions, mainly utilising the skills available in LAs. This would be  
230 essentially at two stages of greening projects: i) appropriate design and implementation, ii) adequate  
231 appraisal of their co-management potentials.

232

233

### 234 *3.3 Case Study III – Managing the trade-offs: Decentralised Energy from Renewable Biofuels*

235 Development of a reliable and clean energy infrastructure has been at the forefront of local planning  
236 framework in recent years, with earmarked potential co-benefits for public health improvements and  
237 for climate change mitigation (Haines *et al.* 2007). Biomass from both organised plantations  
238 (including energy crops) and solid wastes has been considered an integral component of the green  
239 energy mix in the UK towards development of smaller, decentralised heat and electricity applications  
240 in a multiplicity of locations (Barker and Evans 2009, Bauen *et al.* 2010). However, co-management  
241 opportunities from these initiatives have not proven to be effective at a systems level, and there is a  
242 significant risk identified for deleterious impacts on air quality at the expense of lower carbon energy  
243 and heat generation (Gallagher *et al.* 2008). In the UK new sets of guidance have been developed  
244 exclusively for LAs to address adverse air quality issues from biomass boilers and Combined Heat  
245 and Power (CHP) installations. These provide recommendations and spreadsheet-based screening  
246 tools to local managers for assessing and managing the potential air quality impacts, specifically for  
247 nitrogen dioxide (NO<sub>2</sub>) and particulates (PM<sub>10</sub> and PM<sub>2.5</sub>) (EPUK 2009, 2012). It is acknowledged  
248 that the potential risk of a breach of air quality standards is increased if the CHP system is in or near  
249 an AQMA, attributed to the compounded impacts from associated activities at urban and regional

250 scales. However, in the absence of any clear guidance, LAs are left to decide on the level of impact  
251 the installation would have directly within their bounds.

252

253 <place Fig 5 here>

254

255 This case study develops a hypothetical scenario for a decentralised bioenergy system spanning across  
256 two neighbouring LAs (LA1 and LA2 in **Figure 5a**, to illustrate the need for overlapping  
257 responsibilities) and evaluates the CO<sub>2</sub> and air quality issues for utilising a range of renewable fuels  
258 scenarios from the literature. This is pertinent to local planning in the near future, with a growing  
259 number of microgeneration schemes and smaller scale community boilers operating in peri-urban  
260 locations as part of GHG reduction strategy - their environmental responsibilities ought to be shared  
261 across the adjoining LA boundaries. However, LAs would not have direct responsibilities over  
262 imposing emissions control for the whole bioenergy system (for example, harvesting and non-road  
263 transportation and processing of biofuel would not be accounted within the LAQM framework).  
264 **Figure 5(b)** shows a spectrum of air quality burdens arising from different biofuel CHP systems from  
265 the harvest, transportation and power plant (here A=Miscanthus, B= Short rotation coppiced (SRC)  
266 wood, C=Residual waste wood, D=80% Miscanthus + 20% Residual waste wood, E=80% SRC + 20%  
267 Residual waste wood) estimated from emissions reported in the literature (Tiwary and Colls 2010). As  
268 can be noted, all the CHP systems studied have lower CO<sub>2</sub> burdens from the power plant (and hence  
269 promoted as green technologies), albeit at the cost of enhanced NO<sub>x</sub>, N<sub>2</sub>O (nitrous oxide; another  
270 potent GHG constituent), SO<sub>2</sub> (sulphur dioxide) and HCl (hydrogen chloride) emissions. This would  
271 potentially trigger interaction of criteria pollutants, exacerbating health risks from both primary and  
272 secondary pollutants, photochemical smog formation (ozone) and eutrophication (through nutrient  
273 enrichment) in the local environment, as well as impacting on the regional climate from secondary  
274 aerosol formation (Tiwary *et al.* 2012).

275

276 In policy terms this case study highlights the need for strengthening systems scale capabilities to  
277 assess and to effectively mitigate the impacts of such complex and spatially distributed concomitant

278 emissions, spanning across a range of activities involved in fuel harvesting, pre-processing and  
279 consumption. Evidently, such initiatives would ask for a more integrated co-management framework,  
280 with greater cross-territorial interactions between the LAs than currently pursued (i.e. beyond the  
281 basic LAQM approach).

282

283

#### 284 **4. Discussion**

285 The above case studies offer pathways to the manner air quality and climate change can be (and  
286 arguably ought to be) linked within LAs: to ensure the full benefit is obtained from complex win-win  
287 scenarios; to avoid (or at least minimise) the risk and extent of trade-offs where climate related  
288 policies might impact negatively on air quality; to ensure that co-ordinated agendas are taken forward  
289 at strategic levels in order to buy-in support from as many councillors and members of the public as  
290 possible; to be certain that positive impacts across the domains are fully accounted for in cost-  
291 effectiveness calculations for proposed measures. In the short-to-medium term the priority in co-  
292 management practices would be to implement air quality interventions that do not impact negatively  
293 on GHG emissions (Thambiran and Diab 2011) and vice-versa. However, as clearly recognised in  
294 RBC's Air Quality Action Plan (**Table 1**), the sources can differ considerably between the two  
295 management spheres, leading to a need to keep the two separate to some extent. On the other hand,  
296 the overlap between the sources and the interplay between the impacts of both technical and  
297 behavioural remedies for each highlights the opportunity for significant synergies that can be achieved.

298

299 Although, at least in principle, co-management initiatives are expected to be able to attain co-benefits  
300 in terms of both climate change mitigation and air pollution abatement (Baldwin *et al.* 2009), the  
301 majority of existing air quality related legislation has a limited ability to enforce interventions with  
302 such cross-cutting implications and bring about effective improvements. Some commonalities in the  
303 required skill base between air quality and carbon management for LAs have been identified,  
304 including - (a) existing networks of contacts; (b) understanding of gaseous and other emissions; (c)  
305 construction of emissions inventories; (d) understanding of role, behaviour and regulation of a range

306 of sources; (e) identification of priority polluters. However, currently LAQM is predominantly  
307 considered as a health-based framework and thus focussed mainly on the exceedences in areas where  
308 receptors are likely to be exposed to the offending pollutant(s). This provides scope for the sources of  
309 emissions to be isolated and separated from the receptor without the need to reduce overall emissions.  
310 Conversely, carbon mitigation is concerned with reduction in the total load of emissions. Further,  
311 whilst the focus of LAQM is on emissions from sources, much of the work at a local level in terms of  
312 carbon management is in relation to end-use energy demand. For example, in the UK approximately  
313 40% of CO<sub>2</sub> emissions within the scope of influence of LAs arise from electricity usage, rather than  
314 direct emissions (DECC 2011). This means that a significant amount of the focus of any local carbon  
315 management activities would, in any case, fall completely outside the remit of LAQM.

316

317 London City Airport has recently set up a Sustainability Strategy and Airport Sustainability Action  
318 Plan covering 2012-2014 (LCY 2012) where managing both carbon and local air emissions have been  
319 prioritised. The options considered include enhancing natural environment, i.e. vegetation cover;  
320 however, this initiative is severely limited due to space, operational and safety constraints. Based on  
321 the Greenhouse Gas Protocol the emissions from the airport operations have been divided into the  
322 following two categories: (a) Emissions on site, from combustion of fossil fuels; and (b) Emissions  
323 from electricity imported from the grid (or from third party supplier in the form of heat or electricity).  
324 The reported annual CO<sub>2</sub> emissions from the London Atmospheric Emissions Inventory (LAEI) for  
325 2011 in the area close to the airport are considerable (Fig 3a), ranging between  $1.62 \times 10^5$  and  $2.76 \times 10^6$   
326 tCO<sub>2</sub> km<sup>-2</sup>. On the other hand, the maximum annual CO<sub>2</sub> sequestration potential for the vegetation  
327 species evaluated in the region range between 350-830 tCO<sub>2</sub> km<sup>-2</sup> (Fig 3b). Based on our assessment,  
328 assuming optimal vegetation performance, the fraction of local emissions off-set through this  
329 initiative would fall between 0.25 - 15% respectively, depending on whether the aircraft emissions are  
330 included or excluded from the local inventory. This suggests that the greening is more effective in off-  
331 setting ground level CO<sub>2</sub> emissions (mainly from the combustion of fossil fuels, i.e. gas, LPG locally)  
332 and less so in offering a blanket carbon neutrality for the entire airport operations.

333

334 Whilst technological and policy-based strategies have been shown to be effective in simultaneously  
335 reducing air pollution and GHG emissions from the transportation sector (Thambiran and Diab 2011)  
336 there is considerable evidence of LAQM and climate change initiatives still working in silos  
337 (Chatterton *et al.* 2007, Longhurst *et al.* 2009, Faulkner and Russell 2010, Olowoporoku *et al.* 2012).  
338 On the other hand, owing to the inherent distinction between the manner in which the two sources  
339 affect the human and the natural environments this does not necessarily imply that carbon  
340 management can be best achieved at a local scale by following similar policy frameworks and  
341 guidance to those currently used for air quality. This stems from the fact that the co-management  
342 approaches devised to date still have a spatial contrast, carbon management being considered as more  
343 cross-cutting and overarching whereas air quality management manifested into more local, issue-  
344 based initiatives driven by local authorities. Further, as demonstrated through the case studies, the  
345 benefits realised from co-management may not be readily apparent (and precisely quantifiable).  
346 Therefore, while such initiatives appear to be fostering the next generation of local sustainability  
347 measures, they still seem to be lacking the drive, specifically in terms of monetary markets for carbon  
348 mitigation.

349

350 The above three case studies explore the opportunities for linking the two policy spheres through a  
351 single reference point of co-management towards development of a more integrated Climate Change  
352 Strategy Action Plan at local scales, specifically regarding policies on emissions sources from  
353 transportation and decentralised energy. This is proving to be an eye-opener for the majority of actors  
354 involved in overcoming the complexities in integrating local and scientific knowledge. The UK  
355 government policy has long been criticised for not being ‘joined-up’ and it appears that the need to  
356 tackle the cross-cutting and overarching nature of the climate change problem is bringing additional  
357 urgency for this to be resolved. Whilst LAQM has to date had a strong spatial focus, this may partly  
358 relate to its lack of success (e.g. as indicated by widespread failure to achieve EU air quality limit  
359 values). Particularly within the context of an ‘age of austerity’ there will be an increasing need to  
360 argue the benefits of any proposed measure, making a co-management approach one that is more  
361 likely to pass this hurdle when undertaken well. It may also be the case that the resource pressures

362 facing LAs will result in more streamlined, but possibly more co-ordinated structures that may avoid  
363 the large, disjointed departmental structures that reinforce siloed working patterns. These factors all  
364 strongly suggest the need for LAs to develop not just co-management thinking, but also organisational  
365 processes that clearly reveal the logic and benefits of such a strategy. This has for some time been  
366 suggested through using a budgeting approach to sustainable development involving a ‘triple bottom  
367 line’ (financial, environmental and social), but through the case studies presented we have highlighted  
368 that this may not be sufficient and that even the environmental issues will need to be unpacked (into  
369 carbon and air quality at the very least).

370

## 371 **5. Synthesis and Future works**

372 To date LAs in the UK have been set targets for air quality but they have not yet (i.e. in 2012) been  
373 set specific carbon reduction targets as such. Current initiatives, being pursued under the broader  
374 ‘sustainability’ umbrella at LA level, have climate mitigation agenda *per se* with either co-benefits or  
375 adverse impacts to air quality. A well-defined co-management framework, integrating carbon and air  
376 quality management on a single platform, is long overdue. Ideally this needs to facilitate the  
377 practitioners in a two-stage process - first, to develop a common metrics for the LAs, assisting them in  
378 ascertaining whether co-management would be more effective compared to working on air quality or  
379 carbon management in isolation in their respective areas; second, to prescribe them a customised  
380 local/regional implementation plan, linking with the broader strategic objectives at national level. In  
381 essence this would ascertain the impact of co-managing initiatives, albeit inadvertently or by design,  
382 which can manifest into either win-win (e.g. ensuring both lower emissions and freer flowing  
383 transportation) or win-lose/trade-offs (e.g. traffic calming measures adapted for reduced congestion  
384 but increased travel distance circumventing the city routes).

385

386 Whilst a ‘co-benefits’ approach (to a wide-range of other environmental and social factors) has  
387 always been a feature of local planning framework in the UK, there is a spectrum of potential for ‘co-  
388 management’ in the rapidly urbanising economies world-wide, which runs simply from the  
389 assessment of co-benefits, through to complete alignment of policy and management techniques. This

390 paper, however, highlights that in the short-term at least, the delivery of this novel, cross-cutting  
391 agenda may be impeded owing to limited expertise of local managers (developed and developing  
392 world alike) in assessing the synergies and the expected outcome from improved integration of these  
393 two issues. It is expected that a step-change through a more integrated, trans-boundary policy  
394 framework, going beyond the local administrative spheres, would maximise the co-management  
395 potentials while mitigating the wider environment impacts. Whilst a full integration of air quality and  
396 climate change responsibilities in LAs may not (in all cases) be desirable, there is a strong need for a  
397 significant degree of integration to be recommended through adequate policy framework and best  
398 practice. Without this to direct the LAs, there is a huge risk that opportunities to co-management will  
399 be overlooked, ignored, or simply not receive the necessary local political priority.

400

401

402

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407 Authority for providing the emissions inventory for London and to Reading Borough Council with  
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## References

- AQMRC, 2010. Integrating climate change and air quality management at a regional and local level. Air Quality Management Resource Centre. Bristol (UK). [online] Available from :<http://www.uwe.ac.uk/aqm/simon.html>. [Accessed 02 Jun 2011].
- Baldwin, S.T., Everard, M., Hayes, E.T., Longhurst, J.W.S., and Merefield, J.R., 2009. Exploring barriers to and opportunities for the co-management of air quality and carbon in South West England: a review of progress. *WIT Transactions of ecology and the environment*, 123, 101-110.
- Barker, N. and Evans, L., 2009. Evaluation of Opportunities for Converting Indigenous UK Wastes to Fuels and Energy (Report), The National Non-Food Crops Centre (NNFCC 09-012, AEAT), 12 Oct 2009.
- Barrutia, J.M. and Echebarria, C., 2012. Greening regions: the effect of social entrepreneurship, co-decision and co-creation on the embrace of good sustainable development practices. *Journal of environmental planning and management*, 55 (10), 1348-1368.
- Bauen, A.W., Dunnett, A.J., Richter, G.M., Dailey, A.G., Aylott, M., Casella, E., and Taylor, G., 2010. Modelling supply and demand of bioenergy from short rotation coppice and Miscanthus in the UK. *Bioresource technology*, 101 (21), 8132-8143.
- Cantarello, E., Newton, A.C., and Hill, R.A., 2011. Potential effects of future land-use change on regional carbon stocks in the UK. *Environmental science & policy*, 14, 40-52.
- Chae Y., 2012. Co-benefit analysis of an air quality management plan and greenhouse gas reduction strategies in the Seoul metropolitan area. *Environmental science & policy*, 13, 205-216.
- Chae Y. and Park J., 2011. Quantifying costs and benefits of integrated environmental strategies of air quality management and greenhouse gas reduction in the Seoul Metropolitan Area. *Energy policy*, 39 (9), 5296-5308.
- Chatterton, T.J., Longhurst, J.W.S., Leksmono, N.S., Hayes, E.T., and Symons, J.K., 2007. Ten years of Local Air Quality Management experience in the UK: An analysis of the process. *Clean air and environmental quality*, 41 (4), 26-31.
- Chatterton, T.J. and Leksmono, N.S., 2008. Report on process and outcomes of questionnaire and workshop elements of consultation for the development of Reading Borough Councils climate change strategy and air quality action plan. Technical Report. University of the West of England UK, July 2008.

- DECC, 2011. Detailed data supporting CO<sub>2</sub> emissions within the scope of influence of Local Authorities sector and fuel details, Local Authority Emission Statistics, 15<sup>th</sup> September 2011. Department of Energy and Climate Change, London (UK). [online] Available from: [http://www.decc.gov.uk/en/content/cms/statistics/climate\\_stats/gg\\_emissions/2009\\_laco2/2009\\_laco2.aspx](http://www.decc.gov.uk/en/content/cms/statistics/climate_stats/gg_emissions/2009_laco2/2009_laco2.aspx) [Accessed 25 April 2012].
- DECC, 2012. From local carbon frameworks to council frameworks on climate change. How government is empowering local government to take action on climate change? Department of Energy and Climate Change, UK. [online] Available from: [http://www.decc.gov.uk/en/content/cms/tackling/saving\\_energy/what\\_doing/local\\_councils/carbon\\_frames/carbon\\_frameworkes.aspx](http://www.decc.gov.uk/en/content/cms/tackling/saving_energy/what_doing/local_councils/carbon_frames/carbon_frameworkes.aspx) [Accessed 20 Dec 2012].
- Defra, 2011. Air Pollution: Action in a Changing Climate. Department for Environment, Food and Rural Affairs. London, UK.
- Defra, 2012. Green Infrastructure Scoping Study WC0809.Them 1 – Current Condition of Green Infrastructure.4th April 2012.
- DfT, 2010. UK transportation greenhouse gas emissions factsheet. UK Department for Transport, London.
- EC, 2008. Directive 2008/50/EC of the European Parliament on ambient air quality and cleaner air for Europe, 21 May 2008. The European Commission, Brussels.
- EPUK, 2009. Biomass and Air Quality Guidance for Local Authorities England and Wales. Environmental Protection UK, Jun 2009.
- EPUK, 2011. Air Quality and Climate Change: Integrating Policy Within Local Authorities, Environmental Protection UK. [online] Available from: [www.environmental-protection.org.uk/aqclimate/](http://www.environmental-protection.org.uk/aqclimate/) [Accessed 12 Nov 2012].
- EPUK, 2012. Combined heat and power: Air quality guidance for local authorities. Environmental Protection UK, Feb 2012.
- Faulkner, M. and Russell, P., 2010. Review of Local Air Quality Management: A report to Defra and the devolved administrations. Final report to UK Department for Environment, Food and Rural Affairs, January 2010. [online] Available from: <http://archive.defra.gov.uk/environment/quality/air/airquality/local/documents/laqm-report.pdf> [Accessed 17 Aug 2012].
- Fidélis, T. and Pires, S.M., 2009. Surrender or resistance to the implementation of Local Agenda 21 in Portugal: the challenges of local governance for sustainable development. *Journal of environmental planning and management*, 52 (4), 497–518.

- Gallagher, E., Berry, A., and Archer, G., 2008. Gallagher Review of the indirect effects of biofuels production. Renewable Fuels Agency, East Sussex.
- GLA, 2010. London Atmospheric Emissions Inventory 2008. Air Quality Team, Development and Environment. Greater London Authority, August 2010. [online] Available from: <http://data.london.gov.uk/laei-2008> [Accessed 26 July 2012].
- GLA, 2012. Green Infrastructure and open environments: The all London green grid – supplementary planning guidance. Greater London Authority. March 2012.
- Haines, A., Smith, K.R., Anderson, D., Epstein, P.R., McMichael, A.J., Roberts, I., Wilkinson, P., Woodcock, J., and Woods, J., 2007. Policies for accelerating access to clean energy, improving health, advancing development, and mitigating climate change. *The Lancet*, 370 (9594), 1264–1281.
- Hamdouch, A. and Depret, M-H., 2010. Policy integration strategy and the development of the ‘green economy’: foundations and implementation patterns. *Journal of environmental planning and management*, 53 (4), 473–490.
- Hayes, E., Leksmono, N., Chatterton, T., Symons, J., Baldwin, S., and Longhurst, J., 2007. Co-management of carbon dioxide and local air quality pollutants: Identifying the 'win-win' actions. In: *IUAPPA, 2007. Proceedings of the 14th International Union of Air Pollution Prevention and Environmental Protection Associations (IUAPPA) World Congress 2007*, 9-13 September 2007, Brisbane, Australia.
- Larsen, R.K., Swartling, A.G., Powell, N., May, B., Plummer, R., Simonsson, L., and Osbeck, M., 2012. A framework for facilitating dialogue between policy planners and local climate change adaptation professionals: Cases from Sweden, Canada and Indonesia. *Environmental science & policy* 23, 12-23.
- LCY, 2012. Sustainability Strategy and Airport Sustainability Action Plan. London City Airport. Jun 2012. [online] Available from: [www.londoncityairport.com/environment](http://www.londoncityairport.com/environment) [Accessed 10 March 2013].
- LDA, 2011. East London Green Grid: Programme review 2007-2010. London Development Agency.
- London Borough of Brent, 2012. Air Quality Action Plan 2012-15. [online] Available from: <http://democracy.brent.gov.uk/mgConvert2PDF.aspx?ID=8343> [Accessed 23 Nov 2012].
- Longhurst, J.W.S., Irwin, J.G., Chatterton, T., Hayes, E.T., and Leksmono, N.S., 2009. The Development of Effects Based Air Quality Management Regimes, *Atmospheric environment*, 43 (1), 64-78.

- Llausàs, A. and Roe, M., 2012. Green Infrastructure Planning: Cross- National Analysis between the North East of England (UK) and Catalonia (Spain). *European planning studies*, 20 (4), 641-663.
- Naiker, Y., Diab, R.D., Zunckel, M., and Hayes, E.T., 2012. Introduction to local Air Quality Management in South Africa: overview and challenges. *Environmental science & policy*, 17, 62-71.
- Nemet, G.F., Holloway, T., and Meier, P., 2010. Implications of incorporating air-quality co-benefits into climate change policymaking. *Environmental research letters*. doi:10.1088/1748-9326/5/1/014007.
- ODPM, 2001, Assessing Needs and Opportunities: A Companion Guide to PPG17. Office of the Deputy Prime Minister (now the Department for Communities and Local Government), London.
- Olowoporoku, A.O., Hayes, E.T., Longhurst, J.W.S., and Parkhurst, G., 2012. The rhetoric and realities of integrating air quality into the local transport planning process in English local authorities. *Journal of environmental management*, 101, 23-32.
- Quevauviller, P., 2011. Adapting to climate change: reducing water-related risks in Europe – EU policy and research considerations. *Environmental science & policy*, 14 (7), 722-729.
- Ravishankara, A.R., Dawson, J.P., and Winner, D.A., 2012. New Directions: Adapting air quality management to climate change: A must for planning. *Atmospheric environment*, 50, 387–389.
- Raymond, C.M., Fazey, I., Reed, M.S., Stringer, L.C., Robinson, G.M., and Evely, A.C., 2010. Integrating local and scientific knowledge for environmental management. *Journal of environmental management*, 91 (8), 1766-1777.
- RBC, 2008. Stepping forward for Climate Change – Reading’s Climate Change Strategy 2008-2013. Reading Borough Council. Reading (UK). [online] Available from: <http://www.reading.gov.uk/residents/GreenerLiving/ClimateChangeandtheCouncil/reading-s-climate-change-strategy/> [Accessed 15 Nov 2012]
- RBC, 2009. Reading Borough Council Air Quality Action Plan. January 2009, Reading (UK). [online] Available from: [http://uk-air.defra.gov.uk/library/no2ten/documents/Local\\_zone16\\_Reading\\_AQActionplan\\_1.pdf](http://uk-air.defra.gov.uk/library/no2ten/documents/Local_zone16_Reading_AQActionplan_1.pdf) [Accessed 17 Oct 2012].
- Salon, D., Sperling, D., Meier, A., Murphy, S., Gorham, R., and Barrett, J., 2010. City carbon budgets: A proposal to align incentives for climate-friendly communities. *Energy policy*, 38, 2032-2041.

- Stern, N. *et al.* 2007. The Economics of Climate Change: The Stern Review, H.M. Treasury, Cambridge University Press, UK.
- Takeshita, T., 2012. Assessing the co- benefits of CO<sub>2</sub> mitigation on air pollutants emissions from road vehicles. *Applied energy*, 97, 225-237.
- Thambiran, T. and Diab, R.D., 2011. The case for integrated air quality and climate change policies. *Environmental science & policy*, 14, 1008-1017.
- Tiwary, A., Sinnett, D., Peachey, C., Chalabi, Z., Vardoulakis, S., Fletcher, T., Leonardi G., Grundy, C., Azapagic, A., and Hutchings, T.R., 2009. An integrated tool to assess the role of new planting in PM<sub>10</sub> capture and the human health benefits: a case study in London. *Environmental pollution*, 157, 2645-2653.
- Tiwary, A. and Colls, J., 2010. Mitigating secondary aerosol generation potentials from biofuel use in the energy sector. *Science of the total environment*, 408(3), 607-616.
- Tiwary, A., Namdeo, A., Fuentes, J.D., Dore, A, Hu, X., and Bell, M.C., 2012. Assessing the systems scale sustainability implications for city greening. *Environmental pollution*, doi: 10.1016/j.envpol.2013.03.049.
- UNEP, 2011. Towards an action plan for near-term climate protection and clean air benefits. UNEP Science-policy Brief, Nairobi (Kenya), 17pp.
- Van Amstel, A., 2009. Non-CO<sub>2</sub> greenhouse gases: science, reduction policy and implementation, Report of the Fifth International Symposium, Wageningen, The Netherlands, 30 June - 3 July 2009.
- Wright, L.A., Coello, J., Kemp, S., and Williams, I., 2011. Carbon foot printing for climate change management in cities. *Carbon management*, 2, 49-60.

## Tables and Figures Captions

**Table 1.** Policies addressing co-management issues in the Reading Borough Council Climate Change Action Plan (source: RBC 2008)

**Figure 1.** Spatial mapping of the proposed All London Green Grid and the case study area, Lower Lea Valley green space (shown in dotted square). [© Crown Copyright and database right 2011. Ordnance Survey 100032216] (source: GLA 2012).

**Figure 2.** The model domain showing the road and rail traffic (lines), 1 sq-km emission grids, London City airport (rectangle), flight paths (trajectories) and the square box showing the configuration of the green grid. Further details of the spatial layout relative to the street plan and the airport runway locations are provided in the inset. [© Crown Copyright and database right 2011].

**Figure 3** (a) CO<sub>2</sub> hotspot map for London for 2011. (b) Estimated annual CO<sub>2</sub> flux potentials for the case study site (at 1 sq-km grid resolution).

**Figure 4** (a) PM<sub>10</sub> hotspot map for London for 2011. (b) Contour map of PM<sub>10</sub> reduction potentials for the case study site (as concentration reduced downwind to the vegetation at 1.5 m height above ground level).

**Figure 5** (a) Schematic of the conceptualised management boundary of a decentralised bio energy system shared between two local authorities [note: all the activities except biomass production would be accounted within the LAQM, the concomitant interactions of criteria pollution requires a more regional management framework, T = Transportation]. (b) Bar plot of emissions from biofuel-based CHP at systems scale, including biofuel harvest/sourcing, transportation, processing/drying and combustion [A=Miscanthus, B= Short rotation coppiced wood, C=Residual waste wood, D=80% Miscanthus + 20% Waste wood, E= 80% SRC + 20% Waste wood].

## Figures

Fig 1

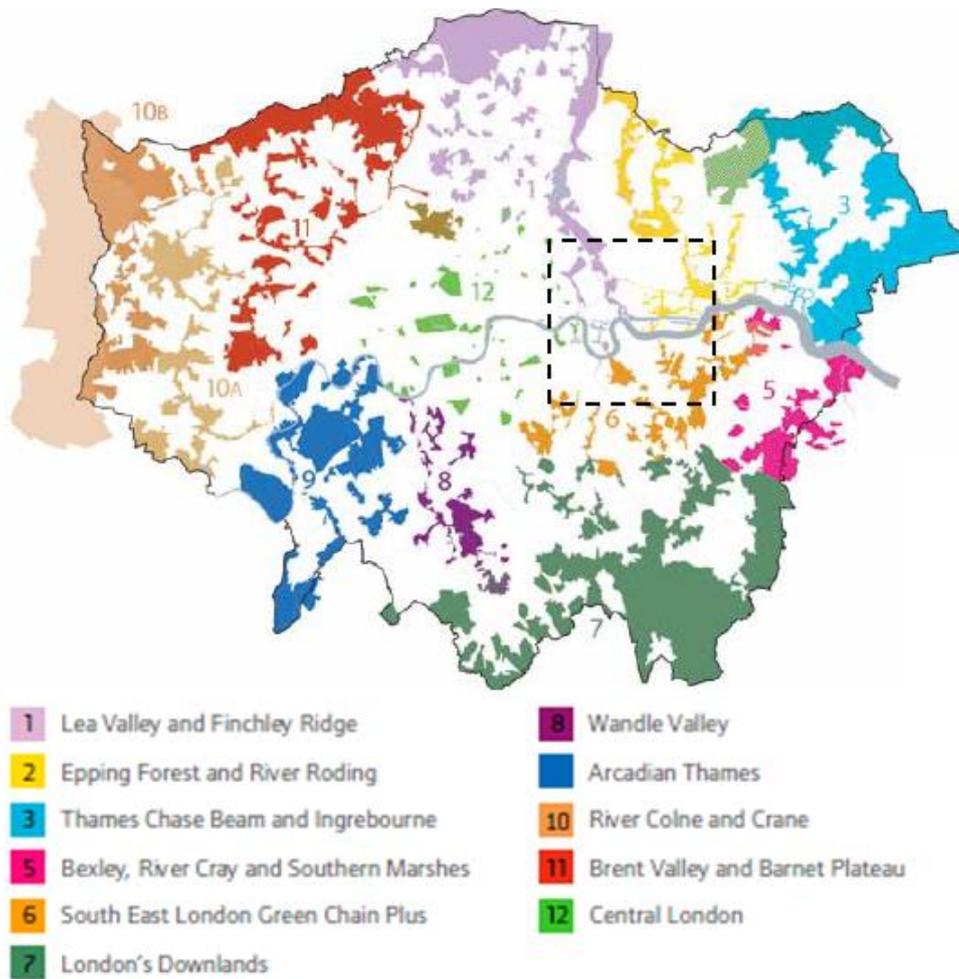


Fig 2.

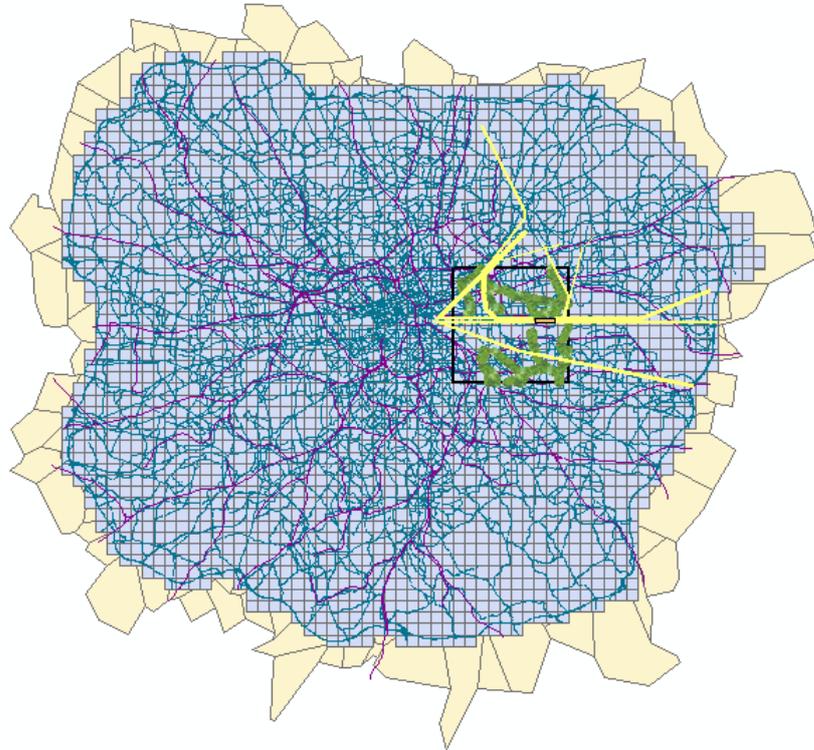


Fig 2 (inset)



Fig 3(a)

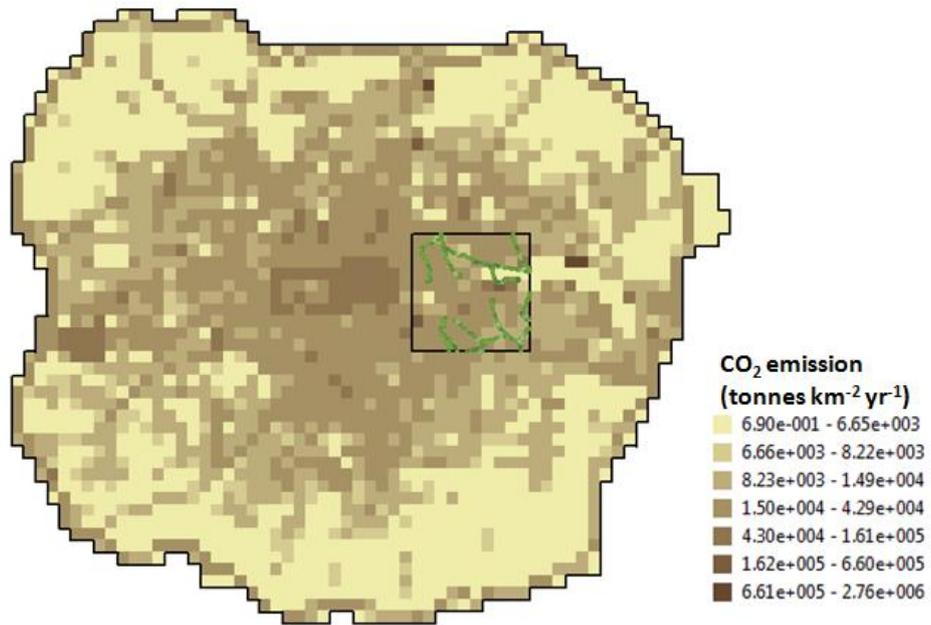


Fig 3(b)

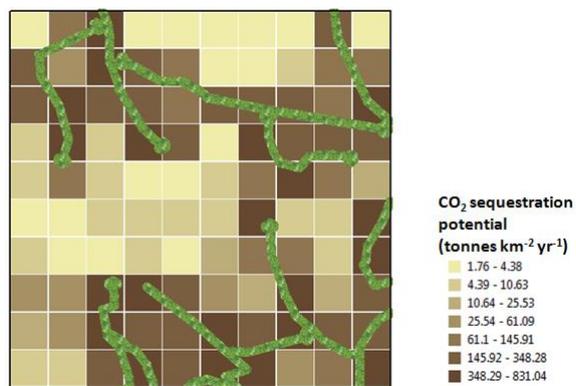


Fig 4(a)

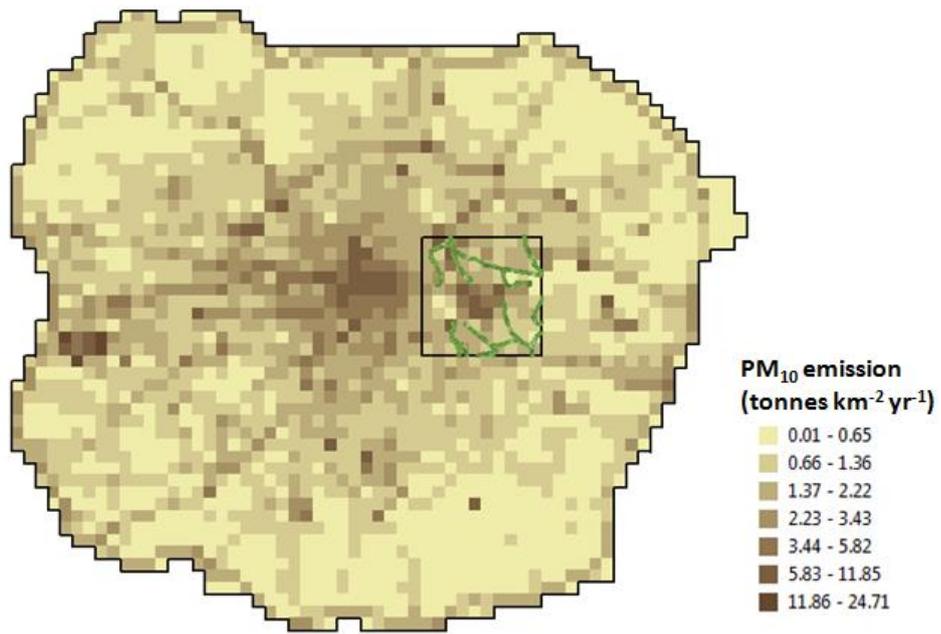


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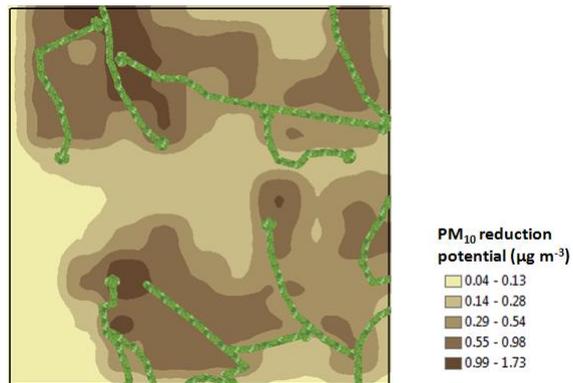


Fig 5(a)

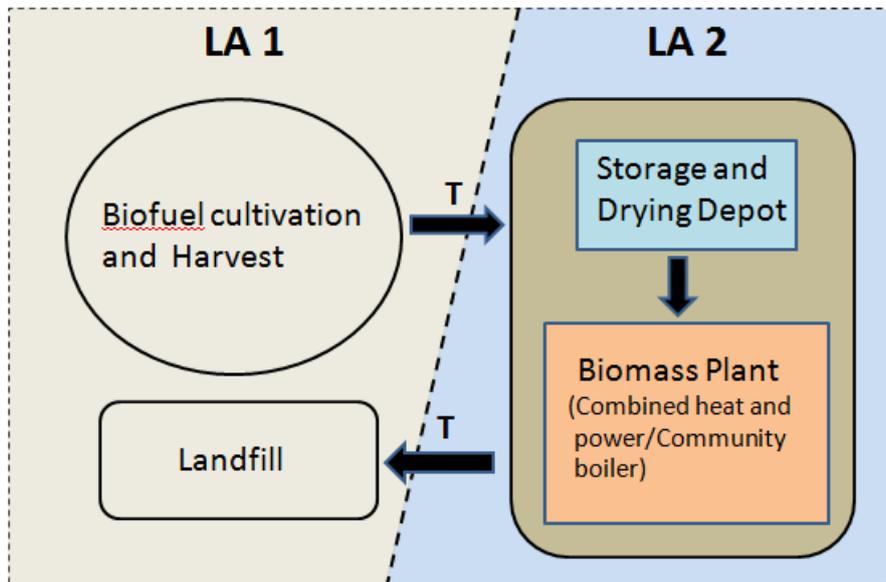


Fig 5(b)

