Chapter 7
Contribution of Urban Agriculture to Food Security, Biodiversity Conservation and Reducing Agricultural Carbon Footprint

Neeraja Havaligi

Abstract Urban agriculture has a definite role in food security in cities. This paper will explore the extent to which urban agriculture contributes to food security in cities with examples from different parts of the world. The paper will explore the potential of urban agriculture in biodiversity conservation in urban and peri-urban areas, its role in reducing the carbon footprint of agriculture, urban food needs and generation of organic waste. The potential for urban agriculture in securing carbon credits for cities will also be explored here.

Keywords Biodiversity · Carbon credits · Carbon footprint · Compost · Energy · Food security · Market · Policy · Urban agriculture

Introduction

Urban agriculture refers to the production of vegetables, meat and dairy products including their processing and marketing in and around urban areas (McCuaig 2006) or peri-urban areas (Bailkey and Nasr 1999). Achieving food security through a sustainable cycle of local resources including local waste produce is documented from the times of Machu Picchu (Vijoen et al. 2005).

Urban agriculture's importance received a mixed response in surveys conducted for this paper. Responses varied from positive, green thumbs up to remarks such as "Urban agriculture is an absurd illusion" and that "growing critical amounts of food on urban spaces is absurd". More than 90% of respondents in the United States thought that urban agriculture is something that is "done elsewhere", as in Cuba, or opined that urban agriculture does not contribute significantly to food security.

N. Havaligi (✉)
6765, Rancho Court, Pleasanton, CA 94588, USA

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About 50% of total respondents were receptive to ideas of edible landscaping and establishing good linkages with peri-urban farms for reasons ranging from recession, increased awareness of the eco-footprint of produce, and the desire to be connected to the process of food production.

Researched evidence and reading literature covering climate change, agriculture, and biodiversity conservation suggests that there is not a strong focus on linking urban agriculture to critical topics of food security, biodiversity conservation and carbon footprint of agriculture.

Urban Agriculture and Food Security

Worldwide about 800 million urban and peri-urban farmers are involved in urban agriculture and contribute to feeding urban residents (FAO, Brook and Davila 2000 and CGIAR 2006). An estimated 14% of the world's food is produced in urban areas through urban agriculture (Armar-Klemesu 2000; Smit 2000). Urban agriculture's contribution to food security is significant in many parts of the world. For example, in Kathmandu, Nepal, 37% of vegetable needs and 11% of animal produce needs are met through urban agriculture (Rees 1997). Intensive cultivation of just 6% of the land area in Hong Kong provides for 45% of its local food needs (Garnett 1996). In Kampala, Uganda, urban agriculture has contributed new job openings for migrant population into the cities in addition to providing vegetables, fruits and over 70% of poultry products for urban consumers (McCuaig 2006).

During WWI and II, more than 20 million home gardens in the United States, known as Victory Gardens, provided food security during the times of war by supplying 44% of the produce consumed in the country (http://sidewalksprouts.wordpress.com/history/vg/). Using less than 3% of land for agriculture, peri-urban agriculture in Australia's five mainland states produces as much as 25% of the total agricultural production in dollar terms (Houston 2005).

According to cityfarmer.org, the most extensive online source on urban agriculture, Cuba has what is believed to be the most extensive urban agriculture programme in Latin America (and probably the world), with more than 2,730 government-operated gardens. The experience of Cuba in urban agriculture was also the most quoted in literature and the interviews conducted for this paper as the best example where urban agriculture contributed to food security in the city.

Urban agriculture in Cuba is a good example of successful urban agriculture. Cuba's comprehensive, highly successful urban food production strategy includes extensive land reform, research and development and technical assistance demonstrating strong government support. In 1998, 541,000 tonnes of food was estimated to be produced in the city of Havana alone for local consumption. Some neighbourhoods in Havana produce as much as 30% of their needs. In 2002, 35,000 acres (140 km^2) of urban gardens in that city produced 3.4 million tonnes of food. In Havana, 90% of the city's fresh produce comes from local urban farms and gardens (Murphy 1999).

Across the world, communities that have taken up urban agriculture with a passion or as a way to address food security issues of migrants, squatters and food deserts have shown that urban agriculture can significantly address food needs and environmental issues.

Interviews conducted with urban and peri-urban farmers in the California Bay Area, Wisconsin, Chicago and parts of Canada, illustrated the significant role of urban and peri-urban farms in providing food security to the cities. For example, Community Sponsored Agriculture or CSA such as Family Farm Fresh, a network of growers within a 50-mile radius of Ivanhoe, California, provides weekly deliveries of seasonal fruits and vegetables plus eggs, honey, olive oil, juice, herbs, and edible flowers to its 300 members.

Full Belly Farm a certified organic farm spanning 200 acres in the Capay Valley of Northern California, supplies produce all year round to three farmers' markets, restaurants and wholesalers on a weekly basis, serving most of Sacramento and Bay Area in California. Its CSA supply of 1,500 boxes of produce per week, 49 weeks of the year, accounts for one third of Full Belly's business. Ninety-nine percent of produce from Full Belly Farm is consumed locally in California.

Interviews with several grassroots community organizations such as People's Grocery, City Slicker Farms, oaklandsol.org in the Bay Area, urban and peri-urban farmers including bee keepers, and government agencies such as parks and recreation department, public health department, etc. reveal that successfully managed urban agriculture including backyard and community gardening could potentially meet up to 30–40% of the produce needs of a city (Havaligi 2009).

City Slicker Farms, for example, produced about 8,000 pounds of food on its farms and 15,500 pounds from the 75 backyard gardens (in an interview with CEO, City Slicker Farms). This, coupled with farms in urban and semi-urban areas in a 100–150 mile radius, could potentially provide for all produce and dietary needs of the city. Jay Salinas, co-director of Growing Power's Milwaukee facility, which works with a network of urban and peri-urban farms in a 150 mile area remarked that Growing Power can meet up to 50% of the food needs of a family of four with its produce box. Growing Power is addressing the food desert issue through this network, community involvement and education.

In Vancouver, Canada, the Strathcona Community Garden, a diverse garden with 290 plots, 200 fruit trees and beehives, produces up to 5,000 pounds of honey in a year (McCuaig 2006). The rooftop farms such as the Millennium Gateway Farms in Vancouver, BC could produce 400–800 tonnes of vegetables (Hohenschau 2005). This garden has teamed up with Home Depot to manage and sell the compost from its vertical composting unit (VCU) that manages 100% of the community's commercial and residential organic wastes. Rooftop farms in Vancouver, BC could provide up to 20% of the vegetables consumed in the community. If sourced regionally, this would have required as much as 200 ha of farmland (Hohenschau 2005).

Urban agriculture's potential to contribute to the food security of cities depends on the city policies on land ownership and use, distribution and management of water and other resources, linkages between urban and peri-urban farms and their communities, direct marketing opportunities through farmers markets, CSAs etc., education and linkages to local schools and hospitals for education and lunch programmes, and universities for outreach, research and development.

Urban Agriculture and Biodiversity Conservation

The Global Biodiversity Assessment states that “overwhelming evidence leads to the conclusion that modern commercial agriculture has had a direct negative impact on biodiversity at all levels: ecosystem, species and genetic; and on natural and domestic diversity” (Heywood and Watson 1995). In both developing and developed countries, international and national institutions and legal structures play a role in agrobiodiversity loss (Wolff 2004). Biodiversity is also threatened by increasing ecological degradation by climate change (Millennium Ecosystem Assessment 2005; Revkin 2008). Crops may skip stages of their life cycle, have delayed or early flowering, seed set, maturity and may and may not be able to complete their life cycle. For example, experiments have shown that corn and soybean plants are likely to grow and mature faster, but will be more subject to crop failures from spikes in summer temperatures that can prevent pollination (Revkin 2008).

“Diversity is the fountainhead of agriculture and food security” (Cummings 2009 via tele-conference). Humans have used about 15,000 plants as food (Facciola 1998) domesticating 7,000 species of plants over the 10,000-year history of agriculture (UNEP 2008). Of these “only 30 account for the vast majority of the food we eat every day” as mentioned by United Nations secretary general, Mr. Ban Ki-moon (UNEP 2008). The world is fed by approximately 20 crops (Facciola 1998). Successful conservation of biodiversity depends on increasing efforts to do things “that have traditionally been outside the scope of the discipline” (Ehrlich and Pringle 2008).

Urban agriculture has great potential to help agrobiodiversity by taking on the cultivation of local varieties under its fold (www.freefarm.org). Urban agriculture provides an opportunity to experiment and grow different varieties suited to different microclimates, thus providing an important avenue for the plants to adapt and perform in the microclimates. Urban agriculture provides a great opportunity for in situ conservation of seed base, but provides an incredible opportunity for the crops to evolve in response to local microclimatic conditions. This kind of evolution is critical for adaptation to climate change. This is the most fundamental response to climate change we can have, to engage with life in the seed (Cummings 2009 via telecon).

When urban communities are linked up through their gardens and seed-sharing networks such as *hyperlocovore.com*, *seedsavers.com* etc., it creates a valuable source to produce and propagate locally adapted varieties that perform well in terms of yield and nutritional qualities. Urban agriculture enhances biodiversity by continued production of rare varieties of fruits and vegetables, which are adapted to local soils and climate (Havaligi 2009). Larger variety of fruits and vegetables are more often seen in small scale farmers (than large-scale growers) thus helping conserve cultivars of unique characteristics and importance to yield and adaptation which may otherwise die out (Garnett 1996).

Urban gardeners contribute to biodiversity conservation when they adopt planting of heirloom varieties and get together into a seed-sharing network. For example, Baia Nicchia (http://baianicchia.blogspot.com/), a small farm in Sunol, California, grows more than 50 heirloom varieties of tomatoes. Baia Nicchia's owner Fred, who breeds and cultivates tomatoes, remarked that small breeders like him and home gardeners are significant contributors to conserving the diversity of genes. He not only grows different heirloom varieties himself but also selects varieties from other home gardens in the area. As John Bela of *sfvictorygardens.org* emphasized: "seed saving and community based genetic diversity is an absolute core of the urban agriculture" (Havaligi 2009).

In India, urban agriculture is playing an important role in the conservation of medicinal herbs in the 14 different kinds of agro-climatic zones. A unique initiative called Home Herbal Gardens launched by Tata Energy Research Institute (TERI) encourages home owners to grow herbal home gardens within their apartment complexes. By distributing a wide variety of medicinal and aromatic herbs, TERI aims to create awareness about the medicinal values of these plants and the need for their conservation.

Urban agriculture has proved to be an efficient mechanism to slow down the loss of biodiversity (Smit 2000) and provide important ecosystem services (Davies et al. 2009) through the urban plant communities, supporting pollinators including birds and other organisms. For example, bee keeping in urban areas is becoming a critical part of maintaining ecosystem services, not just for urban agriculture, but also for surrounding farms where bees have practically disappeared (Havaligi 2009). In addition to pollinating 80% of insect pollinated crops, each hive can produce 100 pounds a year if it is properly tended (Cityfarmer 2009). Declines in some species of birds can be arrested or reversed with proper prioritization and resource allocation to conservation activities in urban areas (Fuller et al. 2009).

Urban Agriculture, Carbon Footprint and Carbon Credit

Currently over 50% of the world population lives in cities, and it is estimated that by 2025 over two thirds of the population will live in cities (UNFPA 2007). Rapid urbanization due to human migration and displacement (CARE 2009) caused by climate change increases the political, humanitarian and financial stakes involved (Zeller 2009a). The urban population in developing countries is growing three times faster (3% annually) than the rural population (less than 1% annually). To feed cities of this size, in some cases over 6,000 tonnes of food is expected be imported each day (Nugent and Drescher 2000).

The current industrial agriculture system is accountable for high energy costs for the transportation of foodstuffs. The average conventional produce item travels 1,500 miles (IDRC 2003) using, if shipped by tractor–trailer, one gallon of fossil fuel per 100 pounds (Pirog and Benjamin 2003). The agricultural sector is estimated to contribute about 28–33% of global greenhouse gas (GHG) emissions (Shattuck 2008). This, with 13.5% emissions generated during the transportation of produce (average bite travels 1,200 miles from field to fork), makes agriculture the single largest contributor to GHG emissions (FAO 2006; IPCC 2007a, b, c).

Large-scale agricultural operations, particularly those dependent on fossil fuels, contribute significantly to GHG emissions in the form of soil carbon, methane from large animal feedlot operations (23 times more powerful than CO_2 as a GHG and are responsible for 18% of global greenhouse gas emissions), and nitrous oxide released from synthetic fertilizers with 300 times the warming power of CO_2 (FAO 2006). We cannot continue to have food prices being driven primarily by the price of fossil fuels (Schill 2008).

Energy consumption and energy loss in agriculture occurs in different ways – use of fertilizers, operation of field machinery, and in irrigation, transportation, processing, and distribution of food and agricultural products. This consumption and loss can be significantly reduced by decreasing the distance that the food travels from point of production to point of consumption, decreasing the time the produce is put away under refrigeration before it is consumed or processed, reducing reliance on fossil fuel-based fertilizer use, and adopting solar farm equipment suitable for small farms.

Urban agriculture has a great potential to use solar-based farm equipment such as the solar tillers and solar charged tractor (Fig. 7.1). Figures from pioneer solar equipment builder Steve Heckeroth illustrate this well: 10 units of fossil fuel energy are required to produce one unit of food energy. Similarly, 8 units of fossil energy are required to produce 1 unit of food energy through global organic agriculture, 6 units of fossil energy for 1 unit of food energy through regional organic agriculture, 5 units of fossil energy for 1 unit of food energy through local organic agriculture, and lastly 0.01 units of fossil energy to produce 1 unit of food energy through solar-charged farm equipment on a small farm (Heckeroth 2007).

The climate bill that was passed recently in the US House of Representatives has the potential to cap greenhouse gas emissions across the United States by cap-and-trade provisions which would effectively raise the price of generating electricity using fossil fuels, and therefore help clean energy technologies – which are expensive relative to coal and natural gas – to become more competitive, thus creating a national market and target for renewable energy production (Galbraith 2009).

Advocates of renewable energy such as Steve Heckeroth think longer term even when facing a history of uncertain funding and markets. A strong feed-in tariff for solar energy, such as the one introduced by the Sacramento Municipal Utility District (SMUD 2009), may help the industry succeed in the long term. Successful uptake of renewable energy requires strong early support from the government to help them compete with cheap existing non-renewable energy resources.

Fig. 7.1 Solar charged electric agricultural tractor designed and built by Stephen Heckeroth, www.renewables.com

Establishing government-backed clean energy loans and subsidies are important in helping the small renewable energy industry to scale up. This, along with supporting clean energy policies, will pave the path for use of solar based farm machinery in urban and peri-urban farms. This is in line with IPCC's statement that in sectors where development of new technologies and new infrastructure is critical to achieving substantial emissions reduction (such as in the waste management sector), financial incentives may perform better than regulations or standards.

Urban agriculture addresses energy issues in food production beyond the adoption and use of non-polluting, zero carbon solar equipment. Utilizing a good network of consumers through local farmers' markets, CSAs and online networks such as http://locavores.com/ and http://www.gardenregistry.org/ to distribute the produce has an even smaller ecological footprint, since the fossil fuel used to transport the produce, and the energy used in refrigeration, packing etc. are significantly lower than conventional agriculture.

Novel for-profit businesses such as MyFarm (myfarmsf.com) in San Francisco, USA and CityFarmBoy (http://cityfarmboy.com) based in Vancouver, Canada, help their customers set up edible gardens, and grade and compost food scraps in their backyards to enrich their own gardens. The team of gardeners in MyFarm work by hand and travel mostly by bicycle. This reduces the carbon footprint of their produce considerably. Cityfarmboy also grows fruit and vegetables commercially in urban gardens and sells through the local farmers' markets, thus decreasing their carbon footprint by reducing food miles significantly.

By being local and small scale, urban agriculture has untapped the potential to establish a close connection between food production and consumption, and to keep the energy cycle tight. This connection becomes stronger with the utilization of local organic waste in local compost that can then be used back in local farms and gardens.

Another important resource, water, is fast becoming scarce. Water sources have become unpredictable; with excess leading to flooding and inundation in coastal and other areas and little or no rainfall leading to severe water shortages and drought-like conditions (Brown 2006; Dore 2005; Hopkin 2005) profoundly impacting the diverse farming regions of the world (McClean et al. 2005; FAO 2006; Revkin 2008). Not only is there a lack of water, but moving water around is highly energy dependent. In California alone, 20% of energy is spent in moving water across the state (Miller 2009). Urban agriculture also provides a logical approach to addressing the increasing demand for water resources through rebooting urban waterways, recycling of grey water and rainwater harvesting in urban and peri-urban farms.

Urban agriculture helps to use this scarce water resource more optimally. For one, it can reuse grey water and degradable biological wastes such as bio-solids and compostable wastes from cities. In the Sydney region of Australia, for example, water reuse in agriculture is thought to have the potential to save up to 32 billion litres of river water per year (DIPNR 2004). Together with the use of bio-solids from Sydney's sewage treatment plants, this has the potential to fulfil the "essence of community ecological management which is the principle of closed nutrition" (Smit 2000).

Urban agriculture can play an important role in municipal waste management (Nelson 1996) by redirecting organic wastes from landfills, and turning it into compost that can then be returned for use in local farms and gardens. Studies shared by Rich Flammer of Hidden Resources (hiddenresources.com) show that in the town of Annapolis Royal, Nova Scotia, to accomplish its zero waste goal, the city has generated an 85% participation rate in backyard and neighbourhood composting, putting out neighbourhood composters for use on streets and multi-family residences and successfully diverted 60% of organic waste into compost. Flammer's work has illustrated that incentives such as lower cost of garbage removal, especially in cities that have a PAYT (pay-as-you-throw) pricing structure, will help motivate people to adopt composting (Havaligi 2009).

Composting can thus be an environment friendly business venture, potentially diverting tonnes of urban organic waste from landfills back to urban and peri-urban farms to replenish the soils there. This produces numerous ecological and economic savings. Composting can receive carbon credits (chicagoclimatex.com). Cities stand to benefit in the long term by providing adequate funding of programmes, revising rules to promulgate composting, establishing good outreach programmes and training concerned stakeholders and agencies to understand the connection between composting, resource management, watershed quality, energy, food supply, and public health.

For urban agriculture to be a success it is important to elicit participation of all stakeholders: local people, farmers, government and municipal bodies, private and public sector educational, banking and marketing institutions. Feedback from interviews indicates that consumers like to make informed choices on the produce they buy.

Green accounting can help in this to get the full cost of the produce. This would include information on where, how, when it was produced and processed, and includes the environmental costs involved in the process until the produce is delivered for sale. Understanding these costs and taxes will provide information to policy makers to recognize current pricing structures, and their financial, ecological, and social impacts on both producers and consumers.

Policy reforms based on these changes will be positive for all areas affected – for urban development, for conservation efforts and for food security. It will also provide viable livelihood and consumption options to producers and consumers alike. Achievement of an efficient system of urban and peri-urban farms supporting the food needs of the city requires a commitment to transparency in decision-making by the various constituents.

Urban agriculture provides a great opportunity to enhance investments in local agriculture and conservation, in resolving the disconnection between the market and social values and in providing viable alternatives for strengthening local economies. Good solutions would require clarifying the appropriateness, need, and urgency of the required changes, in land use, in policies, and investment in supporting infrastructure (Gündel 2006).

Success of urban agriculture requires:

- Utilizing a stakeholder-driven and "bottom-up" approach to providing food security for cities. Stakeholders include, among others, urban and peri-urban farmers, consumers and local and national policy makers
- Providing good development mechanisms for cities to address the climate challenges
- Ability to focus and learn from past and recent climate experience of the local farming community
- Coordination and reevaluation of current research and development policies, priorities and commitments with current and predicted challenges for ecosystem services provided by biodiversity, water and other natural resources. This coordination and reevaluation must be rooted in realistic investments and activities to accomplish goals of sustainable use of resources

The main challenge for urban agriculture to be included in municipal, state and other government policies is to convince people about its urgency and need. This would require a demonstration of its practicality and benefits compared to a business-as-usual scenario in a climate-challenged world.

Achieving food security benefits through urban agriculture will also require a careful analysis of land use dynamics with respect to land used for urban agriculture and land used for other purposes.

Some guiding principles in making a case for urban agriculture in city plans based on feedback received for this research and other sources mentioned are (but not limited to):

- Placing urban agriculture in a food security, local employment and waste management context. Build on known geographical distribution of available land area, diverse community needs, local cultivars and cultivation practices shared between urban and peri-urban farmers
- Recognizing that urban agriculture occurs at different levels – backyards, community gardens, urban and peri-urban farms (FAO 2001)
- Placing emphasis on risks and opportunities of urban agriculture where action needs to be taken in the short, medium and long term
- Early introduction of urban agriculture into cities' plans to encourage wider participation and innovation
- Close coordination between different stakeholders at all levels of planning and implementation (FAO 2000)
- Detailed understanding of local food needs and crop diversity baseline.
- Clear land tenure and rights for the people involved in and practising urban agriculture (Thornton 2009)
- Knowledge of local and regional market policies
- Innovative ways to derive funding to urban agriculture such as carbon credits for composting, carbon credits for local food production and consumption, decreased tax on local produce, etc.

A good urban agriculture policies design will:

- Provide a framework for all stakeholders to develop their own responses to the risks and challenges they face
- Draw adaptation planning efforts, identify actions, delivery, roles and responsibilities across public and private sector organizations
- Determine roles and responsibilities for key organizations
- Provide a checklist to assess the actions needed to build capacity of a community or organization to adopt and practice urban agriculture
- Assist with the development of coordinated, coherent, cross-departmental policy changes with actions involving all stakeholders
- Evaluate value-adding mechanisms such as on-farm processing and direct marketing and seek out new and innovative ways to market urban agriculture products
- Set fair and realistic baselines, accounting for crop loss due to climate change, governance or market challenges, etc.
- Strengthen the capacity of communities to implement plant breeding and seed sharing programmes and develop locally-adapted crops and under-utilized species

Conclusion

If climate change mitigation goals are to be met, international climate policies, negotiations and treaties must consider the crucial role of agriculture (Nelson 2009). Countries urgently need to stimulate the recovery of their local, regional and national food producing capacity, specifically the capacity located in urban and peri-urban agriculture efforts.

Two frequently cited solutions to meet the growing energy and food demands of a population projected to approach nine billion in 2050 are:

- Raising productivity through large investment in fertilizers, irrigation and mechanization
- Extending farming to degraded, abandoned or pasture lands. These solutions would still leave food and energy supplies falling short of demand (Deutsche Bank 2009)

However, with increasing carbon emissions, constraints on resources such as water, land and energy, it is important to explore a "host of options" including "the re-emergence of small, self-sufficient organic farms, characterized as local, multi-crop, energy and water efficient, low-carbon, socially just, and self-sustaining", according to Mark Fulton, Deutsche Bank's global head for climate change investment research (Kanter 2009). Urban agriculture can benefit greatly by support from local banks and government policies. Agricultural growth in and around cities, securing food, and ensuring that people have food sovereignty are necessary criteria on which municipalities and governments must base their policies. This is required not only for global food, but for achieving several of the Millennium Development Goals.

Urban agriculture is a response to urbanization, industrialization and intensification of agriculture with strong national and global backing. It is being recognized as a collective response by us as a species, to establish a relationship of stewardship with the Earth and its resources. It is critically important that we engage in urban agriculture in its many forms where it is appropriate, with a focus on strengthening community-based regional agriculture (Havaligi 2009). With urban agriculture, we take a big step away from fossil fuel-dependent corporate agriculture and a step toward community based regional resource efficient agriculture (Havaligi 2009).

Choices that integrate urban agriculture into the fabric of urban landscapes have the potential to deliver resilience in economic, social and environmental terms, to reinforce the local character of a place in a global context, to build a sense of place and community (Havaligi 2009). By participating in urban agriculture, people understand food and value and respect the farmers who dedicate their lives to growing it.

By networking with local farms in a 150 mile radius, cities can become resilient and powerful by being locally adapted to the regional food system. Cities can strive toward zero waste goals by using urban agriculture to reuse the organic waste generated by the city. The "waste" will be captured and kept within the regional system in form of carrying capacity of the region. It will reduce the carbon footprint of city dwellers and decrease their dependence on fossil fuel.

Urban agriculture is a good way to address food production, food security, energy efficiency problems, which form a significant part of the climate change problem, while at the same time helping the local economies by keeping jobs and businesses in the country. This would also be more politically acceptable in today's economic downturn, rather than waiting for policymakers, governments and others debating the logic of carbon caps (Zeller 2009b) to come to a consensus. Never has the call been as urgent to all the stakeholders in the food system – producers, consumers, policymakers – to come together and work out local solutions through urban agriculture that can both help in adaptation to and mitigation of the global climate challenge.

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References

Armar-Klemesu M (2000) Urban agriculture and food security, nutrition and health. In: Bakker N, Dubbeling M, Gundel S, Sabel-Koschela U, de Zeeuw H (eds) Growing cities, growing food: urban agriculture on the policy agenda. A reader on urban agriculture. Deutsche Stiftung fur internationale Entwicklung (DSE), Germany

Bailkey M, Nasr J (1999) From brownfields to greenfields: producing food in north american cities. Community Food Security News Fall 1999/Winter 2000:6

Brook R, Davila J (2000) The peri-urban interface: a tale of two cities. Gwasg Ffrancon Printers, Bethesda, Wales

Brown P (2006) Global warming: the last chance for change. Dakini Books, London

CARE (2009) In search of shelter: mapping the effects of climate change on human migration and displacement. http://www.care.org/getinvolved/advocacy/pdfs/Migration_Report.pdf

CGIAR (2006) Urban and peri-urban agriculture (UPA). http://www.iwmi.cgiar.org/southasia/ruaf/UPA_Flyer.pdf

CityFarmer (2009) 60,000 Bees on green roof of new Vancouver convention centre. http://www.cityfarmer.info/60000-bees-on-green-roof-of-new-vancouver-convention-centre/#more-1297

Cummings HC (2009) http://www.clairehopecummings.com/

Davies GZ, Fullera RA, Lorama A, Irvineb KN, Simsa V, Gaston KJ (2009) A national scale inventory of resource provision for biodiversity within domestic gardens. Biol Conserv 142:761–771

Deutsche Bank, Climate Change Advise Division of Deutsche Bank, (2009 June) Investing in agriculture: far-reaching challenge, significant opportunity. http://www.dbcca.com/dbcca/EN/_media/Investing_in_Agriculture_July_13_2009.pdf

DIPNR (2004) Meeting the challenges – securing Sydney's water future, metropolitan water plan. Department of Infrastructure, Planning and Natural Resources, NSW, Sydney. http://www.sydneyfoodfairness.org.au/resources/urban_ag.pdf

Dore HIM (2005) Climate change and changes in global precipitation patterns: what do we know? Environ Int 31(8):1167–1181

Ehrlich PR, Pringle RM (2008) Where does biodiversity go from here? A grim business-as-usual forecast and a hopeful portfolio of partial solutions. PNAS 105(Suppl 1):11579–11586

Facciola S (1998) Cornucopia II: a source book of edible plants. Kampong, CA, USA

FAO (2000) Urban and peri-urban agriculture and urban planning. http://www.fao.org/urbanag/Paper3-e.htm

FAO (2001) Special programme for food security. Urban and peri urban agriculture. http://www.fao.org/fileadmin/templates/FCIT/PDF/briefing_guide.pdf

FAO (2006) Livestock a major threat to environment. FAO NewsRoom, 29 November 2006. http://www.fao.org/newsroom/en/news/2006/1000448/index.html
Fuller RA, Tratalos J, Gaston KJ (2009) How many birds are there in a city of half a million people? Divers Distrib 15:328–337
Galbraith K (2009) A funding roadblock ahead for clean energy. http://www.nytimes.com/2009/06/29/business/energy-environment/29iht-green29.html
Garnett T (1996) Growing food in cities: a report to highlight and promote the benefits of urban agriculture in the UK. National Food Alliance/SAFE Alliance, London
Gündel S (2006) A synthesis of urban and peri-urban agricultural research commissioned by the RNRRSS programme. http://www.research4development.info/pdf/ThematicSummaries/Synthesis_study_on_urban_and_peri-urban_agriculture_P1.pdf
Havaligi N (2009) Climate change and food security in the cities. In: Urban research symposium, Marseille, France, 28–30 June 2009. http://www.urs2009.net/papers.html#monday
Heckeroth S (2007) Living without polluting (slideshow shared via email). www.renewables.com
Heywood VJ, Watson RT (eds) (1995) Global biodiversity assessment. Cambridge University Press, Cambridge, UK
Hohenschau DL (2005) Community food security and the landscape of cities. http://199.175.219.1/commsvcs/socialplanning/initiatives/foodpolicy/tools/pdf/commfoodsecurity05aug.pdf
Hopkin M (2005) Amazon hit by worst drought for 40 years: warming Atlantic linked to both US hurricanes and rainforest drought. Nature News http://www.bioedonline.org/news/news.cfm?art=2094
Houston P (2005) Revaluing the fringe: some findings on the value of agricultural production in Australia's peri-urban regions. Geogr Res 43(2):209–223
IDRC/UN-HABITAT (2003) Guidelines for municipal policymaking on urban agriculture. In: Urban agriculture: land management and physical planning. IDRC, Canada
IPCC (2007a) In: Pachauri RK, Reisinger A (eds) Contribution of Working Groups I, II and III to the fourth assessment report of the intergovernmental panel on climate change. IPCC, Switzerland
IPCC (2007b) Working Group II report, impacts, adaptation and vulnerability climate change 2007 – impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the IPCC. IPCC, Switzerland. http://www.ipcc.ch/ipccreports/ar4-wg2.htm
IPCC (2007c) Summary for policymakers in Climate change 2007: mitigation, contribution of working group III to fourth assessment of intergovernmental panel on climate change. IPCC, Switzerland
IPCC Climate Change Report (2007) http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf
IPCC, Geneva, Switzerland, http://www.ipcc.ch/ipccreports/ar4-syr.htm
Kanter J (2009) Farming for 9 billion people. http://greeninc.blogs.nytimes.com/2009/06/25/farming-for-nine-billion-people/?pagemode=print
McClean CJ, Lovett JC, Küper W, Hannah L, Sommer JH, Barthlott W, Termansen M, Smith GF, Tokumine S, Taplin RDJ (2005) African plant diversity and climate change. Ann MO Bot Gard 92(2):139–152
McCuaig A (2006) Social fertilizer: the big growth potential of urban agriculture. Energy Bull. http://www.energybulletin.net/print/20599 and http://thetyee.ca/Life/2006/09/12/UrbanAgriculture/
Miller J (2009) Rebooting urban watersheds. High Country News. http://www.hcn.org/issues/41.10/rebooting-the-urban-watershed-movement/article_view?src=me&b_start:int=3
Murphy C (1999) Cultivating Havana: urban agriculture and food security in the years of crisis. Development Report No 12
Nelson T (1996) Closing the nutrient loop. World Watch 9(6):10–17
Nelson GC (2009) Securing a place for agriculture at the international climate change. In: Negotiations 2020 panel discussion. http://www.ifpri.org/events/seminars/2009/20090327climate.asp

Nugent R, Drescher A (2000) Urban and peri-urban agriculture (UPA) on the policy agenda. In: virtual conference and information market. http://www.fao.org/sd/ppdirect/ppre0073.htm

Pirog R, Benjamin A (2003) Checking the food odometer: comparing food miles for local versus conventional produce sales to Iowa institutions. Leopold Center for Sustainable Agriculture, Iowa

Rees WE (1997) Why urban agriculture? Notes for the IDRC development forum on cities feeding people. City Farmer, Vancouver

Revkin CA (2008) New climate report foresees big changes. The New York Times http://www.nytimes.com/2008/05/28/science/earth/28climate.html

Schill SR (2008) Perfect storm for fertilizer prices. Ethanol Producer Magazine. http://www.ethanolproducer.com/issue.jsp?issue_id=84

Shattuck A (2008) A message for climate change negotiators: small farmers key to combating climate change. http://www.foodfirst.org/en/node/2323

Smit J (2000) Urban agriculture and biodiversity. Urban Agriculture Magazine 1(1)

SMUD (2009) http://www.smud.org/en/news/Documents/09archive/07-17-09_smud_feed-in-tariff.pdf

Thornton A (2009) Pastures of plenty?: Land rights and community-based agriculture in Peddie, a former homeland town in South Africa. Appl Geogr 29(1):12–20

UNEP (2008) http://www.unep.org/billiontreecampaign/CampaignNews/BiologicalDiversity.asp, quote by United Nations Secretary-General, Mr. Ban Ki-moon, 22 May 2008

UNFPA (2007) http://www.unfpa.org/pds/urbanization.htm

Vijoen A et al (2005) Continuous productive urban landscapes. Architectural, Burlington, MA

Wolff F (2004) Legal factors driving agrobiodiversity loss. Environ Law Netw Int 1:1–11

Zeller T (2009a) Making the case for climate as a migration driver. The New York Times. http://www.nytimes.com/2009/06/15/business/energy-environment/15iht-green15.html

Zeller T (2009b) Peacocks and passions on display in senate climate. The New York Times. http://www.nytimes.com/2009/07/20/business/energy-environment/20iht-green20.html