The Relationship between Food Green City and Low Carbon Society

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Abstract

World has already become urban dominated entity living more than 50% of the world's population in cities (set to reach 60% by 2030 and more than 70% by 2050). But, the cities have developed as centers for the secondary (industry) and tertiary (service oriented) economic activities without proper care for primary (basically agriculture) economic activities. The expanding urbanized society is therefore continuously consuming more and more resources and uses the rural lands and rivers/oceans as its waste sinks. Hence, present cities act like parasite, growing and being transformed over the years, consuming resources from nature without giving anything back in return becoming more and more unsustainable.

A tool developed by William Ree's called 'Ecological Footprint' is gaining popularity as a means of getting conceptual idea of level of sustainability. Higher the use of resources for providing food and energy in a city, the value of Ecological Footprint of the city will be higher and vice versa. Resources use in providing food to the city dwellers measured by Food Footprint is one the major component of the Ecological Footprint. Thus, if we want to lower the Ecological Footprint of a city, it is very important to lower the Food Footprint. How can our city become self sufficient in terms of food so that we can lower the Food Footprint? Then, Ecological Footprint will be lower, which means that the place will be more sustainable. In such context of limited resources we have, it was searched a

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way towards urban sustainability and a Concept of Food Green City was developed to practice for productive greening with PLEASURE principles. This hopes to minimize use of resources in the city as a process of urban sustainability.

Similarly, cities are responsible for human impact for environmental degradation including climate change with more than two-thirds of global energy use and greenhouse gas emissions covering just about 2% of the earth's surface. Today, there is 30% more CO_2 in the atmosphere compare to the period at the beginning of the industrial revolution. With the beginning of the 21st century there has been a chain of awaken calls for saving the planet against climate change. By this time, global temperatures have risen by nearly two degrees Fahrenheit than pre-industrial period. Scientists believe that only massive reductions in greenhouse gas emissions can stop the process of global warming. In response to it, a low-carbon society (LCS) adopting patterns of consumption and behavior that are consistent with low levels of green house gas emissions is under discussion and practicing in various cities. Thus, this study tries to analyze the both concept of Food Green Cities and Low Carbon Society comparing their principles and identifying similarities in supporting for the urban sustainability with case study of some relevant selective cities (City of Havana, Dongtan City and 13 Eco-Model Cities) of the various countries (Cuba, China and Japan). This study finds positive relationship between Food Green City and Low Carbon Society and gives some recommendations for the practicability of the implementation to achieve urban sustainability for saving our home earth.

KeyWords: Food Green City, Low Carbon Society, Eco-City, Climate Change, Urban Sustainability.

Introduction

Urbanization has been an inevitable process as a result of which there is increasing number of cities in the world. World has already become urban dominated entity living more than 50% of the world's population in cities (set to reach 60% by 2030). The last century was the century of urbanization and 21st century has been the urbanized world. Urban population is expected to grow to 70 percent by 2050. A city is a system of systems and is the greatest human project that man has ever made. But the rapid urbanization has raised serious environmental problems creating imbalanced city ecosystem. 'The global ecosystem's source and sink functions have large but limited

capacity to support the economic subsystem. The imperative therefore is to maintain the size of the global economy to within the capacity of the ecosystem to sustain. It took all of human history to grow to $ 600 billion/year scale of the economy of 1900. Today the world economy grows by this amount every two years' (Costanza and et al., 1997). The cities have developed as centers for the secondary economic activities (industry) and tertiary economic activities (service oriented) without proper care for primary economic activities (basically agriculture). The rapid conversion of fertile agriculture land into residential buildings, commercial complexes, industrial blocks and many urban infrastructures has greatly influencing built-up and open space ratio affecting badly to the urban ecosystem. Today's cities have difficulty in finding open spaces for healthy breathing and emergency spaces during disaster like earthquakes and fires. Air quality and living environments are greatly polluted, impacting negatively on quality of life. Most of the surfaces of urban areas are generally covered with concrete and asphalt. This process of surface sealing greatly influencing the ground water table and have serious consequences in long run. The sharp decrease of food sufficiency rate of the city year by year has made increasing rate of importing foods. The high energy involved in importing food for the city dwellers from far will consequently increase the cost. It is also becoming the emerging issue of affordability particularly to the urban poor. The expanding urbanized society is continuously consuming more and more resources and uses the rural lands and rivers/oceans as its waste sinks. Cities are thus responsible for human impact for environmental degradation including climate change with more than two-thirds of global energy use and greenhouse gas emissions covering just about 2% of the earth's surface. Therefore, expectation from such an urban planet to the future generation is meaning less. What will the cities of the future then be look like? 'Sustainable development was defined by the World Commission on Environment and Development (1987), widely known as the Brundtland Commission (after its chairperson) as 'Development meets the needs of the present without compromising the ability of future generations to meet their own needs'. Such a definition rightly emphasises the temporal dimension on sustainability but it ignores the spatial dimension and the implications of integration and globalization for sustainability' (Jha et al., 2006). 'Wheeler(1998: 438-9) proposes a helpful process oriented definition of sustainable development: 'Sustainable development is development that improves the long-term health of human and ecological systems' while the sustainable urban development 'improves the long-term social and ecological health of cities and towns' (Sorensen and et al., 2004)' Therefore, modifying our live-styles in a more sustainable way with

consuming less resource is the only option left for us to transfer the urban planet to our future generation. In such context of limited resources, a concept was formulated (as a part of academic exercise for the fulfillment of Doctor Degree in Engineering at Osaka Sangyo University in 2004) that looks green for functional as well as aesthetic purposes shifting green to productive green (green with food) and is designated as Food Green Concept or Concept of Green 21. Photo1 shows a lot of greeneries but these do not carry any meaning to those who are struggling for food and decent living environments. How valuable these trees will be if these trees give the fruits like persimmon and orange (Photo 2)? This sort of realization is in the background behind the evolution of Concept of Food Green. One can realize the importance and the difference between green and productive green from the illustration of Photo 1 & Photo 2.

Photo1: Green

Photo2: Productive Green

In the context of shrinking resources we have for providing food and energy to the city dwellers of the urbanized world and searching a way towards urban sustainability, a Concept of Food Green City was formulated to develop eco-city with **PLEASURE** principles for minimizing use of resources in the city as a process of urban sustainability. Similarly, in response to warning of global warming with excessive use of green house gas emission due to the human activities mostly in cities, Low Carbon Society (LCS) adopting patterns of consumption and behavior that are consistent with low levels of green house gas emissions is under discussion and practicing in various cities. Thus, this study tries to analyze the both concept of Food Green City and Low Carbon Society comparing their principles and identifying similarities in supporting for the urban sustainability with case study of some relevant selective cities of the various countries and explores the relationship between Food Green City (Productive Greening Eco-city) and Low Carbon Society (Less energy consuming society) at three stages:

1) Clarifies what is Food Green City and Low Carbon Society based on literature review.
2) Explores practical approaches or best practices regarding Food Green City and Low Carbon Society based on literature review and case studies
3) Develops a relationship between Food Green City and Low Carbon Society with some recommendations for the practicability of the implementation to achieve urban sustainability for saving our home earth.

Approach and Methodology of Study

This study basically tries to address three questions:

1. How the concept of Food Green City is evolved and it helps to moving towards urban sustainability with some examples of best practices?
2. What is Low Carbon Society and clarify it with describing some of the initiatives taken by Japan?
3. How the Food Green City is linked with Low Carbon Society for contributing towards sustainable urban development?

For supporting analysis both concept of Food Green City and Low Carbon Society few best practices like City of Havana in Cuba and Dongtan in China are selected to link with practicability of Food Green Concept. Similarly, based on the available documents from Internet and books, Eco-cities of Japan are chosen as low carbon society initiatives and targets to study about Low Carbon Society principles and working mechanism. Thus, the method of study involves the review of books and relevant literatures including available internet materials. Some relevant places of cities in Japan are also visited to make ease for the analysis and justification of the theoretical concept. The study findings are analyzed to find the relationship between Food Green City and Low Carbon Society with some recommendations for sustainable urban development.

What is Food Green City?

'A Food Green City (FGC) is a kind of Eco-city that enables its residents to live a good quality of life with minimum consumption of resources, in harmony with nature, culture and future. It is also a process of "restructuring the cities" and its ultimate goal is to establish spatial equity and perfection in urban ecosystem for the sustainable

development with coexistence of man in natural system. The logic behind FGC is gaining "*Something from nothing*" by harnessing light energy (free of cost) for converting it to food energy by means of plants in the city' (Shrestha, 2004). There are eight guiding PLEASURE principles of FGC as mentioned in Box1. Based on the PLEASURE as guiding principles, FGC helps to build the Low Carbon Society (LSC) by reducing GHG emissions and minimizing resource use.

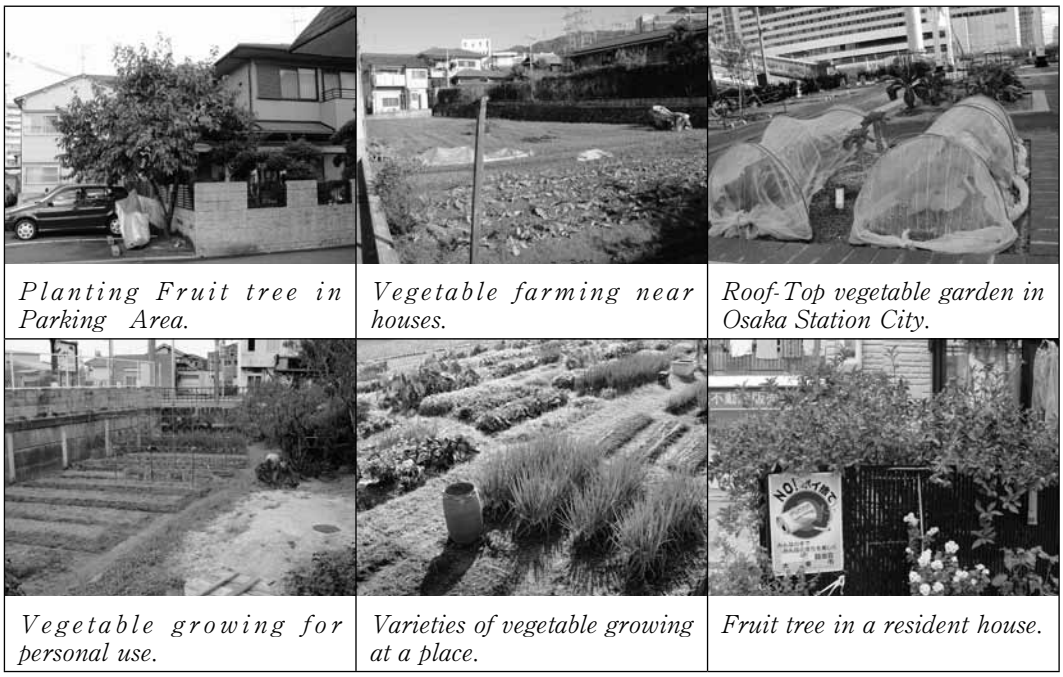
Box1: Eight Guiding (P-L-E-A-S-U-R-E) Principles of Food Green City (FGC)

1. **P**lenty of Food Green Space (Urban Productive Greening).
2. **L**iving and Working Together.
3. **E**nsuring minimum consumption of resources.
4. **A**ttaining sustainable neighborhood through Public Private Partnership.
5. **S**ystem of 3B's (Boot, Bike and Bus).
6. **U**se of energy efficiency and eco-friendly technologies.
7. **R**estructuring the cities through Community participation and local resource.
8. **E**ffort for Zero Waste Emission

FGC has addressed the need of integrating Urban Agriculture with Land Use Planning to combine the benefits of both rural and urban areas in the city and achieving the goal of food self sufficiency for sustainable development. Urban agriculture in Food Green City is any primary activity (horticulture, floriculture, forestry, aqua-culture, herbal & medical plantation, fisheries and livestock production) with primary objective of producing food and maintaining greenery in the city. Urban agriculture in FGC is thus, a vital to city life with a vibrant part of urban economic and ecological systems. The production scale ranges from small in home to community as well as from private sector in city scale commercially with the optimal utilization of urban spaces.

'Support for local agricultural activity-provided that activity is environmentally sustainable-can serve the dual purpose of preserving farmlands at the urban periphery and supporting a local economy that provides for the food needs of the regional population (or at least a significant portion thereof)' (Beatley and et al., 1997). The roles of Urban Agriculture in Food Green city are: rebuilding city with providing food and greenery to the city dwellers utilizing unused and vacant lands; providing affordable food to the city dwellers in an energy efficient manner; providing green jobs to unskilled people and jobless people as well; rehabilitating physical, social and ecological condition of

the city and improving the quality of urban life; revitalizing the culture and community; utilizing organic wastes produced in the city converting into compost thus supporting for waste management and soil nutrient recycling; reinforcing the relationship between Man and Nature; increasing O_2 and reducing the CO_2 accumulation; improving microclimate; and helping to decrease air pollution, maintaining ground water table and keeping bio-diversity. FGC has successfully answers three questions where to do? (Private space, Community space, Vacant Land etc) How to do? (Middle Natural Farming) and Who will do? (City dwellers can do privately at their leisure, Private sectors can involve with PPP modality and community people can do collaboratively). Urban agriculture is not new phenomena; it has been doing in existing situation as shown in Photo 3. But FGC is trying to use it in more organized and integrated form with land use planning for sustainable urban Development.



Planting Fruit tree in Parking Area.	*Vegetable farming near houses.*	*Roof-Top vegetable garden in Osaka Station City.*
Vegetable growing for personal use.	*Varieties of vegetable growing at a place.*	*Fruit tree in a resident house.*

Photo3: Various forms of practicing Urban Agriculture in Osaka

With the advancement of technology various techniques have been in practice to grow more food with less use of space and water. Hydroponic and Perma-culture methods have been under practice, this has made easier to practice urban agriculture as proposed in FGC. To realize Food Green City we have several options as follows:

1. Transforming rooftops into Edible Garden.
2. Converting community open space and parks into Food Green Garden or Parks.
3. Managing the front yard and backyard of the house as kitchen garden for growing vegetable and fruits.
4. With the arrangement of Public-Private Partnership for converting vacant spaces (eg. Vacant land of different organizations, right of ways of roads/highways, river banks, forest land etc) into Food Green Space with growing agro-products without destroying the environment.

It is argued that for urban living 1/4th acre of farmland per average person is required to sustain dietary requirements. As the urban population is growing, agriculture land is decreasing day by day in the cities. So, can city feed its residents with healthy and affordable food, this is the major question to the planners, designers and decision makers?

Therefore, a city must be nurtured and cared by all inhabitants then city can provide food energy and shelter to the city dwellers; such mutual relation must be maintained for the sustainability of a city. With this realization, FGC presents a model that urban environment can co-exist effectively and harmoniously along with the natural environment and trying to solve the city scale problem at city scale beginning with the neighborhood.

In FGC, most of the food that residents consume will be produced in the city itself. This minimizes transportation cost and carbon emission from vehicles. Organic waste is recycled by means of composting and in producing bio-energy, waste water is recycled, rainwater is harvested to use for urban agriculture and other purposes. Thus, FGC offers many benefits for combating greenhouse gas emissions and helps in moving towards urban sustainability with integrating land use planning and urban agriculture. This helps in converting *Carbon dioxide city* to *Carbohydrate city,* decreasing human impacts on urban environments and making the affirmative action for climate positive as demonstrated below.

$$CO_{2\,(gas)} + 2H_2O_{\,(liquid)} + photons \xrightarrow{Chlorophyll} CH_2O_{\,(aqueous)} + H_2O + O_{2(gas)}$$

[Ref. 26)]

More specifically:

$$6CO_2 + 12H_2O + \text{Light Energy} \xrightarrow{\textit{Chlorophyll}} C_6H_{12}O_6 + 6H_2O + 6O_2$$

(Carbon dioxide result of energy consumption) (Carbohydrate result of Productive Greening)

There are already 7 billion populations in the world and most of the land suitable for raising crops has been in use. By 2100, there will be 10 billion people in the world. By the year 2050, nearly 70% of the world's population will reside in urban centers. So it's million dollar question to the city planners, engineers, architects and decision makers is that how will we feed our city dwellers? Sustainability only exists if our cities can modify for coping with change.

- Change in consumption pattern of city dwellers.
- Change in population (increasing trend of urban population)

Cities were originated by mutual interaction of human and natural environment and for sustainability there should be a good balance relation between city and nature. For this city dwellers must take care of it. In the absence of environmental balance and conventional way of growing city has converted city in the form of 'Concrete Jungle'. Hence the present cities have been suffering from complex problem of environmental deterioration and shortage of natural resources. It is therefore more important to think about the relation between city and nature in totality than to solve the problem one by one technically created by unsustainable urban system. Thus, FGC is the complete process for bringing back the system in harmony with nature and shows the path towards future. Its key concept (Fig.1) is simply: "Reducing Energy Consumption and Increasing Production"

Fig.1: Sustainability Concept

Hence, FGC is the rethinking of modern urban system while preserving its positive factors in addition to the attempt towards moving sustainability. Rationality, functionality

and viability are fused along with aesthetic values for driving the present cities towards self sufficiency up to its limits. A Food Green City (FGC) is supposed to compose of sustainable neighborhoods of 250m radius and each neighborhood of FGC (Fig. 2) is regarded as functional entity for optimum self-sufficiency focused on following major elements as follows:

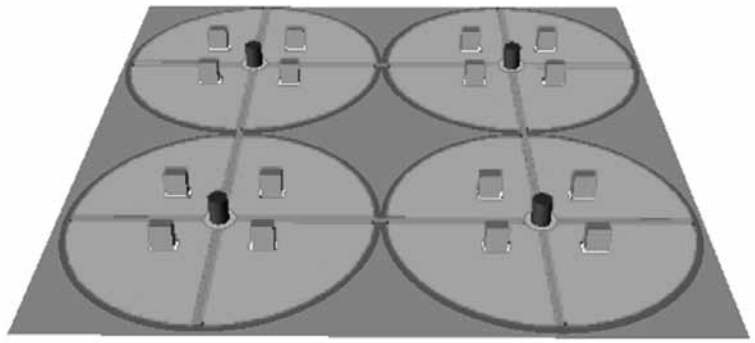


Fig.2: *3D* Visualization of FGC Neighborhood (Source: Shrestha, 2011:)

- Housing and Business complex-Middle High Rise residential buildings are constructed say double twin houses of 6-8 storey for housing people and one Business Complex at centre for working and business including services of the living in the neighborhood based on the principle of living and working together. The rest of the land in the neighborhood belongs to open space, green space, recreational parks and other purposes like composting, waste management centers, parking areas, renewable power generating spaces etc.

- Urban Agriculture-Urban agriculture system around the neighborhood involves large and small scale farm lands/production space for producing food and green spaces in the neighborhood. This reduces Food Mileage from field to fork.

- Energy-Renewable energy sources (wind turbines, solar panels or biogas created from sewage and wastes) are made maximum use in the neighborhood.

- Recycling-Creating environment tending towards zero waste.

- Green Transportation-Provide green paths (Pedestrian paths and cycling tracks) including promotion of 3 Bs and Car sharing opportunities. Therefore the results that can be expected from the development of Food Green City are as follows:

1) Family and community Urban Food Garden in neighborhood and urban agriculture farm in city, which helps to provide affordable and healthy food to the city dwellers.
2) Reduction of food waste and air pollution (from the unnecessary long distance transportation). As the production and distribution occur in the same place, all the waste and pollution caused from the long distance transportation will be vanished.
3) Convert bio-waste to bio-energy as renewable source of energy.
4) Plenty of green spaces in the city keeping healthy environment.
5) Reduces mobility as working and living environment.
6) Energy efficient housing and less horizontal expansion as middle high rise buildings with energy efficient technology like solar, wind and hydro power is used.
7) Less consumption of energy in transportation as mobility is cut by planning itself and there is provision of sustainable transportation mechanism of 3Bs and car sharing.

According to the study carried out by identifying and mapping the potential & viable Food Green Lands in Kitakawachi area of Osaka, Japan; if FGC brings in practice it will be sufficient to attain multi-functional benefits by providing 49% and 23% food self sufficient state and 66% and 31% green spaces of total area in the region respectively with potential and viable lands (Shrestha, 2004). This proves that it is still possible to move towards the significant percent of food self sufficiency state with green urban environment in the region if Food Green Concept is realized in land use planning system. The case study of City of Havana (Fig.3), Cuba given in Box-2 explains how an existing city can be converted from food scarcity situation to the food self sufficient stage supporting for the practicability aspect of FGC. The case study of Dongtan City (Fig.4) of China given in Box-3 will describe more illustratively how the principle taken in the FGC could help in reducing the Ecological Footprint of a city. These two case studies will help in bringing more clarity on Concept of Food Green City and support to understand how principles of Food Green City work for the city to make it more sustainable by reducing energy consumption and balancing our urban activities with change in behavior. The tentative evaluation of Ecological Footprint in average existing city (Ecological Footprint 4.4) and Food Green City (Ecological Footprint 2.3) shows that the Ecological Footprint of a city in Japan can be reduced if Food Green City is realized (Shrestha, 2004). FGC thus proposes a way of living in more sustainable manner in harmony with urbanization in the 21st century.

Fig.3: City of Havana in Cuba (Source: http://maps.google.com/maps?hl=en&tab=ll)

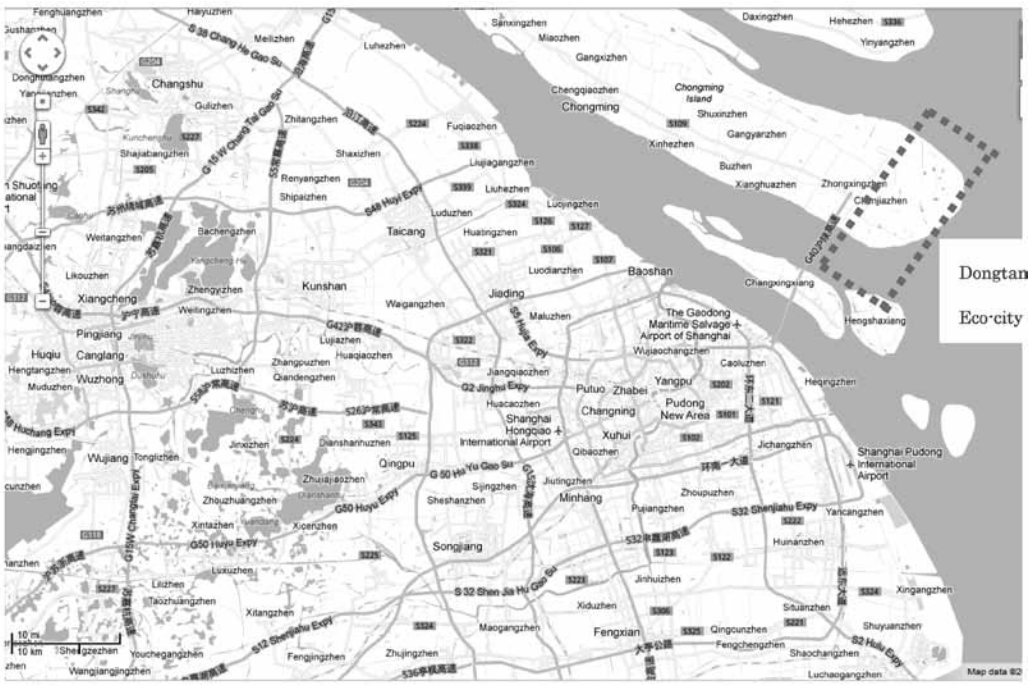


Fig.4: Proposed Dongtan City in Chongming Island of China (Source: http://maps.google.com/maps?hl=en&tab=ll)

Box2: City of Havana: Successful practicing of Urban Agriculture

The city of Havana covers an area of 721 km^2, 0.67% of the total area of Cuba. The city has about 2.2 million inhabitants. The population density is 3,014 persons/km^2. When the Soviet Bloc disintegrated in 1989, 'Cuba lost access of cheap fuel and direct food imports and agricultural inputs from which it was dependent. Import dropped in 19993/94 supplies for agriculture dropped by 67%. Cuba was thrown into a severe crisis, commonly referred to as the 'Special Period'. The crisis was more severe by The US restriction. There is a shortage of petrol necessary to transport the food from the rural agriculture sector to the city. This made a serious food shortage that shook the entire country, but most of all Havana. In response to this city dwellers of Havana started planting food crops on porches, balconies, backyards and empty city lots. 'The Cuban Ministry of Agriculture and Havana' s city government also supported this grassroots movement, jointly forming an Urban Agriculture Department in 1994. This department first focused on securing land use rights for urban gardeners and committed itself to provide land-free of charge-to all residents who wanted to grow food in the city. Today, the Ministry advice and disseminate knowledge based on the principles of organic agriculture and usually plays a pivotal role in the start-up and functioning of the popular gardens and horticulture clubs. They also operate centres, selling agricultural supplies like seeds.

While Havana's urban agriculture has taken on many forms-ranging from private gardens (huertos privados) to state-owned research gardens (organicponicos) Havana's popular gardens (huertos populares) are the most widespread. Cuban statistics are difficult to get, but in 1995 it was estimated that there were 26,600 popular garden parcels (parcelas) throughout the 43 urban districts that make up Havana's 15 municipalities. The popular gardens range in size from a few square meters to three hectares. Shared use of the popular gardens, range from one to seventy people per garden site.

A wide selection of produce is cultivated depending on family needs, market availability and suitability with the soil and locality. Garden productivity has been achieved with minimal external inputs, applying principles of organic agriculture i.e. low cost, readily available, and environmentally sustainable. Farmers often maximize the use of land by cultivating multilayer crops, i.e. crops in the ground, on the ground and above the ground at the same time. A popular combination includes cassava (providing shade), sweet potatoes (providing good ground cover) and beans (fixating the soil with nitrogen).

Havana's farms and gardens are steadily increasing, both in size and number, but most importantly in quality. They have had a visible impact on the food security of the city and in improving the Cuban diet. The gardens also bring environmental benefits.

Sources: 1. Novo, M.G. and et al.

2. *http://sustainablecities.dk/en/city-projects/cases/havana-feeding-the-city-on-urban-agriculture*

Box3: Dongtan: Large Scale Eco-city

In 2005, a consultancy Arup for client Shanghai Industrial Investment Corporation (SIIC) has design a Dongtan city which would exclusively use sustainable energy, be self-sufficient and reduce energy consumption by 66% in relation to its neighbor Shanghai. Dongtan city (3hrs from Shanghai) is designed to house 500,000 people from rural areas with in 2050 in the context that China has to house 300 million people projected to migrate from rural to new cities. The city is planned to cover an area of approximately 86 km^2 (8600 Ha). Today, the area is an important habitat for migrating birds and the city has not yet been realized. If the city is realized and has 500,000 inhabitants, population density will be 5,814/km^2 (58.14/Ha).

This design and planning has main focus on energy-efficient design and technology with quality of urban planning strategies to increase the degree of sustainable development. Design is made such that Solar panels, wind turbines and biomass-based fuels will produce energy to meet demand of the city. Most buildings will have photovoltaic cell arrays on their roofs. A minimum of 20% of Dongtan's energy requirements will be covered by wind power. Dongtan will have much lower housing densities as compare to the nearby Shanghai, but its compact design will still achieve densities 84-112 people per acre, supporting mass transit, social infrastructure, and a range of business. Most homes will take the form of six to eight storey apartment buildings clustered toward the edges. Parks, farms, lakes and other public spaces will offer breathing room between each of the tightly knit districts. Cycling routes, footpaths, and a canal network will provide convenient connective tissue. While safe guarding nearly 60% of the development area is clearly an ecological decision, preservation of the wetland habitat is also expected to draw significant managed tourism to the area. Up to 80% of the city's refuse will be recycled, and some of the organic waste, including rice husks, will be used to make energy to power a combined heat and power plant. Rice husks and other organic waste will be loaded into large bioreactors which will gasify the waste to produce electricity and heat. All the buildings in Dongtan will be designed to intend zero-energy. Gardens or other green vegetation established on the rooftops will provide insulation and filter rainwater, thus helping to reduce energy consumption. The intention is to reduce the ecological footprint of Dongtan to 2.2 ha per person by means of a combination of behavior change and energy efficiency which is comparatively three times less than Shanghai whereby according to the World Wide Fund for Nature, WWF, 1.9 ha is the limit for sustainability.

Sources:

1. http://sustainablecities.dk/en/city-projects/cases/dongtan-the-world-s-first-large-scale-eco-city
2. Farr, D., 2008

The Case Study I-City of Havana clearly illustrated that how an existing dense city can utilize its vacant lots for growing healthy food locally and able to keep the green environment practicing urban agriculture building food self sufficient society with sense of community. The case study of Dongtan City (Fig.4) supported by adaptation of principles similar to FGC in many aspects and demonstrated how a large scale eco-city can be designed for real world for reducing ecological foot print with modifying conceptual way of urban planning and designing system. However, Food Footprint constitute large share [about 40% (Nepal), 36% (Japan) and 30% (Australia)] in Ecological Footprint calculation, in the design of Dongtan City it still found lacking to take more visible steps for achieving food self sufficiency while designing is noted. So, needs of local food production sufficiently should be considered in such newly designed eco-city.

What is Low Carbon society (LCS) and what are its principles?

A low-carbon society (LCS) adopts patterns of consumption and behavior that are consistent with low levels of greenhouse gas emissions. It demonstrates a high level of energy efficiency and use low-carbon energy sources and production technologies. By taking actions that are compatible with the principles of sustainable development, the development needs of all groups within society are ensured. LCS is based on the following principles [Ref. 20)]:

1. Minimize CO_2 emission in all sectors (private, government and citizen).
2. Towards less consumption society.
3. Coexistence with Nature

Developed countries are moving towards consumption society. Non renewable source of energy like fossil fuel is the major source of energy for this modern society and these days there is serious attention is towards Peak Oil, which is the point in time when the maximum rate of petroleum production is reached, after which the production rate will enter its terminal decline. Some optimistic estimate towards Peaking oil will hope to be coming soon about 2020 or 2030 while pessimistic prediction is that it has already occurred or will occur soon. But as consumption of oil use is increasing, the time will come definitely if precaution is not taken in time seriously and consumption is not mitigated before peak. If this happens availability of oil will decline and price will rise unbelievably and result affects global social economical and environmental

condition badly. This directs to change the consumption society to sustainable society. Population resource consumption of developed countries are so high that if everyone of the world would like to live in the same way, resource available in this planet is not sufficient and it requires three more planets to live in a sustainable way. Therefore for sustainability of this planet we need to have Low Carbon Society moving from four planet society to one planet society. Another reason why we need LCS is-to maintain climate system. However, it is still under debate that 'carbon-dioxide concentration is not a cause of climate change' (Aoki, I.) but it is real fact that with the increase of human activity, resource consumption is in increasing trend and green house gas emission level is also increasing. And whatever the reason, global temperature is also increasing. Such increases in temperature carry profound risks. Even with small increase in temperature is likely to have remarkable impact on the ecosystem and may result negative consequences to human lives and other species due to climate change (extreme rainfall, drought etc). According to the Third Assessment Report (TAR) of the Intergovernmental Panel on Climate Change (IPCC): 1^0C rise in global average surface temperature compared to the pre-industrial lever will have significant impact on ecosystem; 2-3^0C rise will have negative impacts on agriculture, water resources and human health; and above 3^0C will bring serious risks of large scale irreversible system disruption like destabilization of the Antarctic ice sheets. Scientists have discovered that the concentration of CO_2 in atmosphere was just above 370ppm in the atmosphere which has result the global mean temperature rise of 2^0C. In order to not exceed 2^0C from the pre-industrial level, global green house gas (GHG) reduction target needs to be about 50% of 1990 s emission level in 2050 and 75% in 2100. 'Carbon dioxide (CO_2) is the most important anthropogenic GHG. The main sources of atmospheric CO_2 are from the burning of fossil fuels used in transportation, heating and cooling of buildings and manufacture of cement and other goods.' (UNHabitat, 2011). This emphasizes that the reduction of CO_2 emission is most essential for the development of LCS.

As shown in the Fig.5 developed countries have higher GNI and also higher GHG emission per person with compare to the developing countries and Least Developed country. And it is clearly seen in the figure that two curves GNI and Carbon dioxide emission per capita for the various countries are following the similar pattern indicating with rise of GNI per capita increases the CO_2 emission per capita showing the consumptive pattern of society. Therefore it needs to design change the consumption behavior and move towards Low Carbon Society.

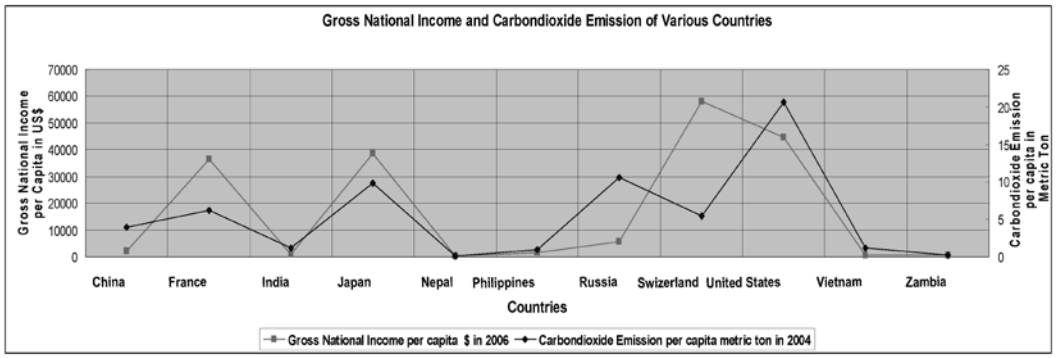


Fig.5: Gross National Income and Carbon dioxide Emission per capita (Data source: The World Bank 2008)

LCS has to be looked as a global scenario and its implication are different for different countries based on its development stage. Every country of the world has to make sincere effort to establish low carbon society to save our only one planet from global warming. By middle of the 21st century if an effort to establish a low carbon society with reducing global emissions by half from the current level, developed countries would need to reduce emission by 70%-80% from the current level and developing countries would have to keep approximately the current level while achieving economic growth and improved quality of life. Such a society cannot be realized if the current trends continue. This needs change for consumption pattern with minimization of carbon linking human activities more closely towards the nature.

Japan-UK Low Carbon Society project (2006) has a major component as an international modeling comparison exercise, 'Low Carbon Society (LCS) Scenarios Towards 2050', under taken by nine national team with a strong developing nation focus. Based on this there has been made a vision to seek the possibility of a Low Carbon Society into a reality. Japan Low Carbon Society project is a good example. 'This envisages a world in which global temperature rise is held below 2^{0}C, global CO_2 emission are cut by 50% by 2050, and Japanese emissions are cut by 70%. However, a key conclusion is that more than one path of social development is consistent with this outcome. The research team constructed two contrasting visions of a Japanese low-carbon society. Vision A ('Doraemon') is the technology–driven, with citizens placing great emphasis on comfort and convenience. They live urban lifestyles with centralized production systems and GDP per capita growing at about 2% per anum. Vision B ('Satsuki and Mei') is of a slower-paced, nature oriented society. People tend to live in decentralized communities that are self-sufficient

in that both production and consumption are locally based. This society emphasizes social and cultural values rather than individual ambition' (Skea, J. and et al.).

'In 2007, Japan announced its aspirations of becoming a low carbon society with the aim of making a transition from a fossil-fuel dependent industrial society to a low carbon one; creating new business in Low Carbon City (LCC) in the spirit of "Mottainai"; establishing long-term goals to reduce 60-80% of CO_2 emissions by 2050 with emission levels at their peak within the next 10-20 years; and promoting concrete actions for LCC ' [Ref. 9)] .

Japanese Government selected 13 Eco-Model Cities (EMCs) out of 82 applications opening application from April 11to May 21, 2008. The selected cities (Fig. 6) are as follows below.

Major Cities: Kitakyushu, Kyoto, Sakai, Yokohama

Regional Core Cities: Iida, Obihiro, Toyama, Toyota

Small Cities and Towns: Shimokawa, Minamata, Miyakojima, Ysuhara

Special Tokyo Ward: Chiyoda

Fig.6: 13 Eco-Model Cities of Japan (*Source:* http://www.jetro.org/content/807/)

Table 1: Introduction of 13 Selected Eco-Model Cities for Low Carbon Society

Name	Location	Characteristics	Population	Area (km^2)
Shimokawa	Hokkaido (Kamikawa District)	● Farming ● Forest (90%)	3800	644
Obihiro	Hokkaido (Tokachi Region)	● Agriculture based ● Large scale farming on upland and diary	170000	619
Yokohama	Honshu (Greater Tokyo Area)	● Major Commercial Hub ● Major Port City	3.67M	434
Toyama	Honshu (Capital of Toyama Prefecture)	● Extremely dependent on cars ● Gasoline consumption per household is second highest in Japan	420000	1242

Name	Location	Characteristics	Population	Area (km^2)
Kitakyushu	Kyushu (Nothern Part)	● One of the four largest industrial zone ● Important role in modernization of Japan	0.99M	488
Minamata	Kyushu (Kumamoto Prefecture)	● One of the worst environmental disasters caused by pollution of bay from industrial dump.	29000	163
Chiyoda	Honshu	● Home for important national and diplomatic offices ● Political and Economic Centre of Japan	45000 850000 (daytime)	12
Iida	Honshu (Nagano Prefecture)	● Alpine wilderness area ● Cultural, Economic and Administrative centre of southern Nagano Prefecture	107000	659
Toyota	Honshu	● Home of Toyota Motors ● 70% of area covered with forest	420000	918
Kyoto	Kyoto Prefecture	● Historic places with many temples, shrines and garden ● 50 million tourists every year ● Natural beauty with $3/4^{th}$ area covered with forest	1.47M	828
Sakai	Honshu (Osaka Prefecture)	● Historically largest and most important seaport of Japan connecting foreign trade with inland trade	840000	150
Yusuhara	Source of Shimato River with landscape underlain by limestone	● Small town covered by 91% forest and fields	4000	237
Miyakojima	Par of Okinawa Prefecture	● Tourist Destination visit by more than 400000people each year ● Sugarcane, the local natural resource	55000	205

The brief introductions of those 13EMCs are given in Table1 and Strategic Targeted Plans and interventions for moving towards LCS are given Table 2. Strategic Actions Plans for EMCs were announced in April 2009 to lead the realization of the local model that Local Carbon Society and Sustainable Economy can go together. Government is willing to provide support for their implementation of action plans to transform Japan into the Low Carbon Society and serve as best practices showcase of various forms.

Also Promotion Council for the Low-Carbon Cities (PCLCC) was established in 2008 to disseminate best initiatives of EMCs to other cities and communities and develop action plans toward the drastic reduction in carbon emissions. It also shares information relevant policies and actions to public both inside and outside Japan.

From the Table 2 it is clear that the strategies proposed to transform the selected EMCs towards LCS are:

1. Individual behaviour changes
2. Policy measures of local governments.
3. Technology innovation and diffusion of existing technologies
4. Participation of citizens and local communities
5. Widespread of Renewal Energy
6. Transformation of living styles
7. Development of Efficient Transportation System
8. Waste minimization and Efficient Waste Management
9. Promotion of agriculture and forestry
10. Collaboration between People, Government, Private Sector and Research Institutes

More precisely it is observed that the approach taken by EMCs by different categories of cities selected to transform to LCS are:

1. Large cities-Building Eco-friendly urban infrastructure, Transportation reform,
2. Housing reform, Energy Utilization Structure reform.
3. Regional Core Cities-Achieve Compact City, Develop Public Transportation Network
4. Small Cities-Utilize natural and renewable sources of energy at local context

Table 2: Proposed plan of 13Selected Eco-Model Cities for Low Carbon

Name	Reduction Goal	Proposed Strategic Plan	Compatible Principle of FGC
Shimokawa	32%(2030) Mid-Term 66%(2050) Long-Term Base year:1990	A LCS in Harmony with the Forest ● Local Resource Utilization ● Low Carbon Housing Project ● People Participation	➢**E**nsuring minimum consumption of resources. ➢**R**estructuring the cities through Community participation and local resources.

Name	Reduction Goal	Proposed Strategic Plan	Compatible Principle of FGC
Obihiro	30%(2030) Mid-Term 50%(2050) Long-Term Base year: 2000	A rural environment Model City ● Promoting Agriculture	➢**P**lenty of Food Green Space (Urban Productive Greening).
Yokohama	Over30%/ person (2025) Mid-Term Over60%/person (2050) Long-Term 2004	A City Wide Zero-Carbon Lifestyle ● Use of renewable Energy ● People Participation	➢**U**se of energy efficiency and eco-friendly technologies. ➢**R**estructuring the cities through Community participation and local resources.
Toyama	30% (2030) Mid-Term 50% (2050) Long-Term Base year: 2005	A Compact City Strategy for Low C02 emission ● Promotion of Public Transportation	➢**U**se of energy efficiency and eco-friendly technologies.
Kitakyushu	30% (2030) Mid-Term 50-60% (2050) Long-Term Base year: 2005	A Green Frontier City ● Recycling Industries ● Unused Energy Supply System ● Combined efforts of PPP+RI	➢**R**estructuring the cities through Community participation. ➢**E**ffort for Zero Waste Emission ➢**A**ttaining sustainable neighborhood through Public Private Partnership.
Minamata	33% (2020) Mid-Term 50% (2050) Long-Term Base year: 2005	A Sustainable Small Scale Municipality ● Waste Management and Recycling	➢**E**ffort for Zero Waste Emission
Chiyoda	25% (2030) Mid-Term 50% (2020) Long-Term Base year: 1990	Building an Energy-Conserving City and Improving Energy Efficiency	➢**U**se of energy efficiency and eco-friendly technologies.

Name	Reduction Goal	Proposed Strategic Plan	Compatible Principle of FGC
Iida	40-50%/ residential sector (2030) Mid-Term 70% (2050) Long-Term Base year: 2005	Building a Low Carbon City Using Renewable Energy through Citizen Participation ● Use of Renewable Energy ● Citizen Participation	➢**U**se of energy efficiency and eco-friendly technologies. ➢**R**estructuring the cities through Community participation and local resources.
Toyota	30%-50% (2030) Mid-Term 50%-70%(2050) Long-Term Base year: 1990	Urban Development and an Eco-friendly Car Society Through Cutting–Edge Environmental ● Intelligent Transportation Systems used to reduce traffic congestion ● Prioritize public transit	➢**U**se of energy efficiency and eco-friendly technologies. ➢**S**ystem of 3B's (Boot, Bike and Bus)
Kyoto	40%(2030) Mid-Term 60% (2050) Long-Term Base year: 1990	A Pedestrian-Centered City Using Community Power to Create a Low Carbon Society ● With local resources building new models for living and working in the city	➢**S**ystem of 3B's (Boot, Bike and Bus) ➢**L**iving and Working Together
Sakai	15%(2030) Mid-Term 60% (2050) Long-Term Base year: 2005	Advanced Environmental Industry Solar Panel Construction and Recycling Factories ● Low Carbon Industrial Complex ● Energy Conservation by all business ● Creation of sustainable public Transit network ● Establish Sakai Eco University to provide practical environmental course work and training	➢**U**se of energy efficiency and eco-friendly technologies. ➢**S**ystem of 3B's (Boot, Bike and Bus) ➢Restructuring the cities through Community participation and local resources.
Yusuhara	50%(2030) Mid-Term 70% (2050) Long-Term Base year: 1990	Woody Biomass Community Cycle Model Project ● A Low Carbon Mountain Village using local resources ● Fuel from woody pallets ● 100% self sufficient in energy installing hydroelectric power, wind power and solar power	➢**U**se of energy efficiency and eco-friendly technologies. ➢Restructuring the cities through Community participation and local resources.

Name	Reduction Goal	Proposed Strategic Plan	Compatible Principle of FGC
Miyakojima	30-40%(2030) Mid-Term 70-80%(2050) Long-Term Base year: 2003	Energy from Sugarcane Produced locally ● Create self-sufficient energy supply system	➢**P**lenty of Food Green Space (Urban Productive Greening). ➢Restructuring the cities through Community participation and local resources.

The strategies proposed are relevant for the local context but needs to be done more in the following aspects to achieve the target:

1. Government initiatives for green buildings and energy efficient technologies, transportation and industrial sector; emphasis must be given more on behaviour change of the people for reducing the CO_2 emission. Motivation and education must be given to the consumers to be conscious about energy saving and changing from high carbon lifestyles to low carbon lifestyles.

2. Instead of given priority for one or two strategies, integrated approach combining applicable all strategies at local context must be apply.

3. Follow up of the EMC Strategic Action Plans must be done regularly, assess the performance and review plan of action accordingly it for getting the targeted goal. Best practices and approaches must be shared nationally and internationally. EMC should be spread throughout the Japan to achieve effective result.

Some of the initiatives practicing in various cities of Japan for moving towards LCS are illustrated in Photo4.

Intelligent Transportation System

Preservation of Forest

Reliable Mass Transit System

Photo4: Various forms of practicing towards LCS in Japanese Cities

Analytical Findings

Greenhouse gas emissions are caused by a variety of sources from different sectors like transportation, housing and industry etc. contributing to the emissions. Any solution to fight against global warming must therefore be multi-faceted. Cities can adopt low carbon options by planning efficient city structures, controlling urban sprawl, developing efficient public transport, and increasing the food production and use of renewable energy. The characteristics of city structure itself offer important opportunities for sustainable living. As discussed above Food Green City (FGC) being the place of combination of sustainable neighborhoods producing food locally, compact in structure adopting the principle of living and working together with efficient housing facilities

with Mid-High Rise Apartments, reduces the energy use technological innovation and behavior changes and also uses renewable energy, emphasizes on waste reduction, rain water harvesting, recycling waste water and restructure the cities with collaborative efforts of PPP. Promotion of urban agriculture in the city not only supplies affordable healthy food in the city it also provides to cut the energy use for controlling temperature if it is used in the large buildings and cities appropriately. This is further verified by the study done by Y. Kitaya and his team. 'Sweet Potato was cultured with a lightweight hydroponics system on a rooftop as cooling equipment for reducing urban heat island effects and also as urban agriculture in a summer season in Osaka, Japan. In the result, the difference in surface temperatures between concrete plates exposed to sun light and under the vegetation coverage were increased with increasing solar radiation flux and reached 13^{0}C. The tuberous roots yield was 3.2 kg/m^2 in this method. Sweet Potato culture in rooftop farming will be a promising practice for environmental conservation in urban areas' (Kitaya,Y and et al., 2009).

FGC can also play significant role for limiting urban sprawl with optimum density but with plenty of productive greening space beautifying the neighborhoods and focusing towards green infrastructures. FGC has provision of collective middle rise housing system for living & buildings for working and decentralized service system with proper land use planning making living, working and service hubs together. The effective transportation plan it has designed to promote 3B's system reduces mobility and transportation emission. These all efforts will minimize the travel, shares resources and reduces greenhouse gas emissions which in turns help to lower per capita energy consumption. FGC has included city level adaptation strategies like energy efficient building construction; emphasis on the green infrastructure (parks, ponds etc.) development; proper waste management system ("less waste" policies, energy recovery from waste, recycling and reusing waste); promoting clean technology and design; using renewable energy (solar and wind energy) as much as city can. The use of those technologies can help for constructing eco-housing, energy efficient buildings and green infrastructures, which help to bring down CO_2 level.

In contrary to conventional cities moving towards a high energy-use and conventional economic model, FGC follows green economic model (one that conserves energy) that can radically reduce ecological footprint. This ensures a more sustainable lifestyles moving from present four planet lifestyles towards one planet lifestyles. Hence, FGC has

various practical and affordable components for turning the possibility of a Low Carbon Society into a reality. Realizing the importance of urban agriculture and its suitability for the urban development of Nepal, Government of Nepal has recently started to study some of its cities how those cities can be developed as Eco-city incorporating Urban Agriculture system. Also development of guidelines for urban agriculture system has been initiated.

Successful practice of urban agriculture in the existing city with remarkable food self-sufficient state as described in the case study of City of Havana shows validity of the converting existing city to FGC and obviously helps for reducing the Ecological Footprint as Food Footprint of the city will lower remarkably. Similarly, design of Dongtan city which adopted similar integrated approaches of FGC has expected to reduce Ecological Footprint remarkably (66% less than conventional city) further highlighted the positive direction towards Low Carbon Society if integrated approach of FGC can be realized in practice. From the study of 13 EMCs of Japan it is clear that Obihiro city has taken strategy of promoting agriculture; Shimokawa is planning to develop low carbon housing project with utilizing local resources and people participation; Yokohama city is focusing on use of renewable energy; Kitakyushu in recycling industries and collaborating with different stakeholders including private sector and Research Institute; Minamata emphasizing on waste management and recycling; Chiyoda trying to improve in energy efficiency in the city; Iida also preparing to utilize renewable energy through citizen participation; Toyota prioritizing on public transit and Intelligent transportation system; Kyoto is developing pedestrian centered city; Sakai trying their best for energy conservation by all sectors; Yusuhara is trying to be self-sufficient in clean energy; and Miyakojima planning to create self-sufficient energy supply system from sugarcane produced locally; for moving towards Low Carbon Society.

Table 3: Relationship Matrix

LCS Principles	Minimize CO_2 emission	Towards less consumption society	Coexistence with Nature
Compatible FGC Principles	➢ **P**lenty of Food Green Space (Urban Productive Greening). ➢ **L**iving and Working Together. ➢ **E**nsuring minimum consumption of resources. ➢ **A**ttaining sustainable neighborhood through Public Private Partnership. ➢ **S**ystem of 3B's (Boot, Bike and Bus). ➢ **U**se of energy efficiency and eco-friendly technologies.	➢ **P**lenty of Food Green Space (Urban Productive Greening). ➢ **L**iving and Working Together. ➢ **E**nsuring minimum consumption of resources.. ➢ **S**ystem of 3B's (Boot, Bike and Bus). ➢ **U**se of energy efficiency and eco-friendly technologies. ➢ **E**ffort for Zero Waste Emission	➢ **P**lenty of Food Green Space (Urban Productive Greening). ➢ **E**nsuring minimum consumption of resources. ➢ **R**estructuring the cities through Community participation and local resource.
Result	**Compatible and positively Linked**	**Compatible and positively Linked**	**Compatible and positively Linked**

All the approaches taken by those selected EMCs are similar to the principles described by FGC. So, with no doubt we can say that the approaches and principles of FGC and LGC are similar and in other words the integrated approaches of FGC for developing cities based on PLEASURE Principles is an effective eco-city model valid for both existing and new cities for building Low Carbon Society. From all these above deliberation, the result of how the relationship between Food Green City and Low Carbon City based on conceptual basis supported by case studies and the study of 13 EMCs cities is presented in the Relation Matrix given in Table 3.

Conclusion and Recommendations

Conclusion:

From the above study of Food Green City and Low Carbon Society, it can be concluded that FGC is an effective means for reducing energy use & CO_2 emission and achieving quality of life in coexistence with Nature that belongs to the principles of LCS. The integrated approach which aims for integration of Urban Agriculture with Land Use Planning and follows PLEASURE principles by FGC has great potential in contributing the sustainable urban development and achieving Low Carbon Society. Therefore, there is a positive relationship between FGC and LCS and in summary it can be said that FGC is a reliable, practical and sustainable path towards LCS.

Recommendations:

1. The relationship established between Food Green City and Low Carbon Society by this study is just primary attempt and conceptual basis. It has opened door for further investigation in more details and deeply. Thus, this has explored the opportunities for designing real scale Food Green City for moving towards Low Carbon Society and then finding out the relationship more precisely, it is the first recommendation of this study.
2. There are many types of Eco-cities designed and practicing for moving towards Low Carbon Society for less attention has been found given in the productive greening of the city or provided sufficient Food Green Spaces as prescribed by FGC. Since, local food production has many benefits as described above in reducing Ecological Footprint and reducing energy cut for transportation and distribution of food from farm to fork, it is highly recommend to consider serious for providing food green spaces and local food production system in any kind of eco-city and Low Carbon Society to be designed and practiced.
3. Low Carbon Society depends upon multifunctional parameters. There exists no specific approach for building Low Carbon Society. Looking at the complexity of Low Carbon Society instead of caring towards few parameters towards reducing carbon emission and energy use, integrated approach of dealing with various major parameters for minimizing the resource use and CO_2 emission is a better way to achieving Low Carbon Society as followed by FGC.
4. Two visions [Vision A (Doraemon or Technology Driven and emphasis on convenience & comfort) and Vision B (Satsuki and Mei or Nature driven and Self sufficient)] exists for moving towards Low Carbon Society. Winning the Nature is impossible and unless and until we are not been able to learn to live with respecting nature and its laws, sustainable development is beyond our reach. Therefore, Vision B as FGC is following to move towards Low Carbon Society is highly recommended.
5. Uncertainty in future is showing unlimited possibilities. But we have to identify the way that moves towards certainty. The first decade of the 21_{st} century has been a chain of awaken calls for saving the planet against climate change. The future is thus beckoning us for huge promise for taking steps now to try and prevent further climate change rather than mitigate its effects later–when it is already too late. This needs energy efficient and low carbon producing cities. Looking at direct strong link between cities and climate change, cities major responsibility is obvious. Thus, the time for 'Conventional City' is over. Cities are therefore needed to be redefined and

restructured for sustainability. We have to now make more efficient, sustainable, affordable, equitable and resilient city like **Food Green City** for combating the challenge of global warming with moving towards Low Carbon Society. Therefore, it is high time for change our lifestyles and face the global challenge of climate change building the resilient city like FGC for moving towards Low Carbon Society for saving our home 'Earth'.

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