A Novel Planning Model for Approaching a ‘Zero’-Food and ‘Zero’-Waste Community

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Abstract

Green building codes normally consider self-sufficiency of energy and water. Their highest aspiration is to build zero carbon buildings (ZCB) or zero energy buildings (ZEB). However, a zero-energy building is not sustainable, as it does not take into account the self-sufficiency of food and waste. This paper puts forward a novel planning model to approach a zero-food and zero-(organic) waste community (ZFW community), paving the way to achieve a truly sustainable community with four-zeros on energy, water, food, and waste. It considers a community of 40-ha land accommodating 10,000 persons. If 8-ha farmland is additionally provided, then it can achieve 100% self-sufficiency in fertilizer (organic waste) and 40% self-sufficiency in vegetables. It does not only save carbon dioxide emission due to transportation of food and waste, but it also helps reduce 40% of the landfill space.

1. Introduction

An urban city accommodates a large population for commercial and housing activities, and normally consumes the nature much more than it can produce. For example, WWF (2013) [1] reports that Hong Kong is consuming 2.6 Earths, which is a significant biocapacity deficit and there are only eight countries that have a bigger per capita biocapacity deficit than Hong Kong.

However, the main contributor to Hong Kong’s household-related ecological footprint is not energy category (which accounts for just 14%), but food category (which accounts for 23%). In other words, even if buildings can all be zero-energy and zero-water, the city cannot be sustainable without self-sufficiency on food and waste. As mentioned in the report, a city heavily dependent on imported food does not only result in an unsustainable living style, it “could easily and rapidly become a national security issue” and “is in a particularly vulnerable position” [1].

Unfortunately, so far almost all certification schemes of green buildings ignore self-sufficiency of food and fertilizer (organic-waste). Almost all of them are developing building services engineering and architectural building designs to achieve the zero-energy and zero-water goals; however, zero-food and zero-waste goals have been completely ignored so far.

In line with the definition of zero-energy building, a zero-food and zero-waste (ZFW) community does not mean consuming no food and disposing no waste. But instead, it means a self-sufficiency of food and fertilizers (obtained from the organic-waste of the community).

However, unlike a green building design, a zero-food and zero-waste concept cannot yet be achieved by building services engineering or architectural designs. It requires a novel urban planning model that includes farmland, thereby striking a balance between food consumption and production. It expands the scope of green development from a building design dimension to an urban planning perspective.

The following sections review the related literature, and set out two scenarios for comparison and evaluation of the benefits of the ZFW community. The two scenarios are: (1) 100% dependence on imported food and exported-waste; and (2) 40% self-sufficiency on food (vegetables) and zero-(organic) waste.
2. Literature Review

Green building codes normally consider self-sufficiency of energy and water, such as LEED, BREEAM and BEAM certifications. Their highest aspiration is to build zero carbon buildings (ZCB) or zero energy buildings (ZEB). For example, the EU has set the target of building nearly Zero-Energy Buildings (nZEB) with effect from 2020.

A zero energy building is defined by Kilkis (2007: 220) [2] as “a building, which has a total annual sum of zero energy transfer across the building-district boundary in a district energy system, during all electric and any other transfer that is taking place in a certain period of time.” In other words, if the operating energy consumed by a building from the grid can be offset by on-site renewable energy generation with grid-feed-in, then it is regarded as a ZCB (CIC, 2012 [3]).

Similarly, a zero-food and zero-waste community does not necessarily mean zero food consumption or zero waste production in the community, but can be defined as a community with self-sufficiency in food (vegetables) and fertilizer (from organic-waste) production and consumption. If the food and fertilizers consumed by a community can be offset by on-site food and organic waste production by trades, then it can be regarded as a zero-food and zero-waste community.

However, it cannot be sustainable if the food consumed and the waste disposed within the community cannot be largely self-sufficient. It is, therefore, an imperative to consider food and waste self-sufficiency for a sustainable community.

For example, the latest certification standard, “Living Building Challenge” of the ILFI (2012) [4] does not only address net zero-water and net zero-energy goals, etc., but it also requires a proportion of urban agriculture, based on an inverse relationship with the floor area ratio (FAR or plot ratio) of the development. Unfortunately, it does not consider the self-sufficiency of food and waste, but simply fixes some percentages of urban agriculture. Contradictory to the food self-sufficiency concept, it allows exemption of urban agriculture for a FAR larger than 3.0. In other words, the higher the food consumption, the less food production facility is required.

Even though the current LEED standards have incorporated a new Sustainable Food strategy since 2009, giving credit for acquiring food within a 100-mile (i.e., 161 km) radius, etc., it does not consider self-sufficiency of food (vegetables) and fertilizer (organic-waste). Yet, if an urban farm can be provided for each community, then it certainly achieves the LEED’s sustainable food strategy.

In fact, many green certification bodies (e.g., United States Green Building Council and Green Building Council of Australia) have realized the limitations of just certifying buildings, and have gone beyond building scale and introduced new tools for assessing buildings, spaces and systems for a community, and cared about connectivity, site ecology and communal infrastructure. The Hong Kong Green Building Council (HKGBC, 2013 [5]) has also just started to develop a rating tool for assessing sustainable neighborhood in Hong Kong. However, most of these tools do not take into account zero-food and zero-waste achievements.

Indeed, there have been very few attempts to identify the spatial requirements for self-sufficiency of food and fertilizer in a community, even though the concept has been raised for decades. For example, Howard’s (1902) [6] Garden City has proposed to site a city within a belt of open countryside for agriculture and food supply, but he could not image the population density and the scarcity of land in today’s urban areas.

Then, self-sufficiency of food has been totally neglected in the latter half of the 20th century, due to the availability of more-than-enough and affordable food in developed world, by means of a globalized, high-tech and efficient food production-and-distribution system based on neoliberal market reasoning, as well as the ignorance of external environmental impacts. It was not until the global warming issue, peak-oil and food-price spikes emerged that the model of food self-sufficiency in a community was revised (Lang and Miao, 2013 [7]).

More recently, some municipal governments and scholars have devoted more attention to community food systems (Blay-Palmer, 2009 [8]; Carey, 2011 [9]; Rocha and Lessa, 2009 [10]; Morgan and Sonnino, 2010 [11]; and Roseland, 2012 [12]), but most of them are based on city level, and they do not elaborate how a city planner or an architect can plan for a sustainable community with a self-sufficiency of food and fertilizer.

3. Cost-benefit analysis of ZFW community

If zero-energy building is regarded as the sustainable development model 1.0, then technically the goal is now achievable. The ZCB HK and the greenest building Netherlands 2012 are two of the examples. This paper, however, pursues a sustainable development model 2.0, i.e., a planning scheme for approaching a 4-zero sustainability (zero-energy, zero-
water, plus zero-food and zero-waste) within a community.

The following analysis will explain why it is extremely difficult to achieve self-sufficiency of food and fertilizer in a high dense urban community. The scheme outlined below does not only work out the layout plan for a ZFW community, but it also raises a novel standard of sustainability for developments in the future, and for researchers to work towards the transition to low-carbon sustainable economies which can improve urban life.

This paper considers a community in Hong Kong with a medium population density of about 40-ha (400,000 sm) of land for accommodating about 10,000 people, i.e., population density of about 25,000 persons/sq.km. This is about the current average population density of the urban area in Hong Kong. The urban density of Hong Kong is one of the highest in the world, it ranks the top fifth highest density of the global urban cities in 2012 (Demographia, 2013 [13]).

The reasons for taking this size of the community are at least two folds. First, the area is small enough to neglect transportation costs of food and waste within the community. Second, the population size is big enough to achieve the economies of scale of a sustainable community.

By taking the current average number of person per housing unit (2.5), the population of the community can be accommodated by providing 4,000 typical high-rise housing units of each 100 sm in gross floor area. Then, the footprint of buildings would account for 2 ha land (see Table 1). But restricting the maximum FAR (or plot ratio) to be 5, the total land area designated for residential development should be 8 ha. To balance the land use requirements for the community, it also provides 24 ha land for commercial use, open space, government / institution and community (GIC) and other uses (Table 2). In other words, only 8 ha remaining land areas are available for agriculture.

### Table 1 Population and Housing Footprint

| Descriptions                  | Qty | UOM |
|-------------------------------|-----|-----|
| No. of blocks                 | 25  | ea  |
| No. of storeys                | 20  | ea  |
| No. of housing units per storey | 8   | ea  |
| GFA of each housing unit      | 100 | sm  |
| Total no. of housing units    | 4,000 | ea. |

| Total footprint area          | 20,000 | sm |
| Total GFA of housing          | 400,000 | sm |
| Persons per housing unit (say)| 2.5  | persons |
| Total population accommodated | 10,000 | persons |
| Total land area for housing (say) | 80,000 | sm |
| FAR (or plot ratio)           | 5     | na  |

### Table 2 Land Use Distribution for the Community

| Land Use     | Area (ha) | %  |
|--------------|-----------|----|
| Residential  | 8         | 20.0% |
| Commercial  | 6         | 15.0% |
| GIC         | 4         | 10.0% |
| Open space  | 4         | 10.0% |
| Agriculture | 8         | 20.0% |
| Others (incl. roads) | 10 | 25.0% |
| Total        | 40        | 100% |

4. Scenario A: A 100% import dependent community

The current average consumption of vegetables per 10,000 persons per year in Hong Kong is about 1,000 tons. If all the vegetables consumed are imported from mainland China, say, then the carbon dioxide emission for transporting the vegetables per year would amount to 100-700 tons, depending on the distance from the closest to the furthest farms in the mainland and the consumers in Hong Kong currently (Yiu et al., 2013 [14]).

Furthermore, the current average weight of organic (kitchen) waste per 10,000 persons per year in Hong Kong is about 1,825 tons (ENB, 2013 [15]). The carbon dioxide emission of transporting the waste to the landfills can amount to 467 tons, depending on the distance from the landfill to the source of kitchen waste. Worse still, most of the landfills in Hong Kong are almost full, the disposal of the organic waste is a waste of the limited landfill space.

The sole reliance on imported food also makes people expose to toxic food with contaminated substances and vulnerable in case of a food crisis. It also results in a large-scale abandonment (more than 4,000 ha) of farmlands in the New Territories, some of
them are converted into dumping sites for wastes or open burning and car dismantling sites (AFCD, 2013 [16]). Man et al. (2013: 774 [17]) found that these activities would “release a large amount of PAHs and bind with SOM [toxic substances], which would potentially jeopardize environmental and human health.” Remediation for the contaminated sites is required before a safe agricultural production can be carried out.

5. Scenario B: a 40% food self-sufficient community

The current average production of vegetables per 1 ha land per year is about 50 tons, and the current average consumption of vegetables per person per year is about 100 kg (AFCD, 2013 [16]). It, therefore, requires 20 ha land to achieve self-sufficiency in vegetables (1,000 tons) for the community of 10,000 persons, at the current agricultural technologies (If all the vegetables are required to be “organic” production, then the land and labor input will even be higher than for conventional products).

Taking this highest production rate, the 8 ha agriculture land in the community can only produce 400 tons of vegetables every year, i.e., 40% self-sufficiency of vegetables only (Table 3). It can help cut 40% of the carbon dioxide emission in the transportation of vegetables as well.

Table 3  Self-sufficiency Rate of Vegetables

| Descriptions                               | Qty | UOM |
|-------------------------------------------|-----|-----|
| Average production of vegetables per ha per year | 50  | tons|
| Average consumption of vegetables per person per year | 100 | kg  |
| No. of people in the community             | 10,000 | persons |
| Land areas for vegetable growing           | 8  | ha |
| If 100% self-sufficiency of vegetables, it requires | 20 | ha |
| Vegetable self-sufficiency rate by providing 8 ha agricultural land | 40 | % |

According to an on-site record of one of the farms at Fanling, Hong Kong in 2013, 1 ha farmland can take in about 240 tons of organic waste to produce fertilizer per year, thus the 8 ha community farmland can absorb 100% of the kitchen waste produced in the community, achieving a zero-(organic) waste community (Table 4). It, therefore, saves all the emission of carbon dioxide due to the transportation of waste to the landfill, and helps reduce 40% of the landfill space, according to the ENB (2013 [15]) statistics.

Table 4  Consumption Rate of Kitchen Waste

| Descriptions                                               | Qty     | UOM |
|------------------------------------------------------------|---------|-----|
| Average amount of kitchen waste per person per year         | 182.5   | kg  |
| No. of people in the community                              | 10,000  | persons |
| Total amount of kitchen waste per year                      | 1,825   | tons |
| Average amount of kitchen waste that can be consumed by 1 ha farmland | 240 | tons |
| Farmland areas required for consuming all the kitchen waste | 7.60    | ha |

The development of community farming can also ensure a satisfactory supply of safe and high quality food. Wong (2002) [18] verified that most of the soil in the New Territories is fertile and suitable for growing food, except the brownfields. Furthermore, the development of community farming would provide employment opportunities as organic agricultural production is a labor-intensive activity. Wong (2002) [18] showed that a farm of 1,000 sm could create five working positions if running under organic farming mode.

In our proposed 8 ha community farming site, it can generate about 400 working positions, out of the 10,000 residents (4%). It would further make the community more sustainable and livable if the farm works can be done by the residents of the community themselves. As ULI Singapore (2011) [19] contended that a mixed-use community is one of the 10 principles for a livable city, community farming can help provide
job opportunities to low-income and low-skilled residents or retired persons in the community.

With the increasing public attention to food safety, the demand and market price of organic vegetables in Hong Kong are promising. By means of a recent survey of local organic farmers’ markets, Yiu et al. (2013) [14] found that the market price of organic vegetables can now be sold at more than 5 times the price of traditional imported vegetables. A farmer’s wage can be higher than the minimum wage of the city.

6. Conclusions

The most recent IPCC’s (2013) [20] report alarms that the evidence of human influence on global warming has grown since the last report, but we are still struggling to transit from our current fossil fuel economies to low-carbon economies which can sustain our urban life. In the past 20 years, green buildings have been developed, and nowadays zero-energy and zero-water buildings have become achievable.

However, there have been very few considerations on green community with self-sufficiency of food and waste. With the recent rapid trend of urbanization, problems of food security and lack of landfill sites are envisaged. It is, therefore, urgent to work out master plans for zero-food and zero-waste communities, together with zero-energy and zero-water.

This paper identifies the spatial requirements for approaching a ZFW community. The plan is of 40 ha land accommodating 10,000 persons. It is found that with 8 ha farmland, the community can achieve 40% self-sufficiency in vegetables, and 100% self-sufficiency in zero-(organic) waste.

It requires 20 ha of land for a 100% self-sufficiency of vegetables, without taking into account the production rate drop by producing organic vegetables. Other foods, such as rice, fruits and meat, have not been taken into consideration. It reveals the great hurdle in achieving self-sufficiency of food.

Furthermore, the added agricultural activities in the community would consume a lot more energy and water, it requires some further studies to work out how to keep it zero-energy and zero-water in a ZFW community. We are also going to do some scenarios checking in further studies, by varying land area, housing density, farming productivity, kitchen waste, etc. Moreover, in future studies we will analyze price and wage effects as well as organic food labelling to guarantee food security of vegetables produced in zero-food and zero-waste communities.

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