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Planning for peak oil: learning from Cuba's 'special period'

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It is against recent experiences of proliferative consumption of the earth's resources that planners and politicians must confront the challenge of peak oil over the coming years. With so few examples of peak oil available worldwide, this paper explores the realities of this in Cuba after the collapse of the Soviet Union in 1989 – the so-called special period, which decimated the country's imports of energy, food and other vital supplies. Drawing on primary research collected in Cuba during 2008 and in an attempt to stimulate debate about how western countries and cities might respond to future losses of global resources, this paper examines the policy responses implemented in Cuba in the fields of transport, spatial planning, agriculture and energy. Despite the Cuban situation being politically different from other countries and the fact that the loss of resources during the special period were abrupt and unplanned, it is argued that there is still considerable scope for a wider application of the concepts to other towns and cities, if not countries and cultures.

1. INTRODUCTION

From governments to local communities, all areas of society must prepare for the 'triple crisis': the combined effects of global warming, peak oil and depletion of the world's key resources (e.g. food), which are converging at the same time (PCC, 2007). The doubling of crude oil prices from \$72/barrel in 2007 to \$150/barrel in 2008 (EIA, 2008) represents one of the most severe price spikes experienced by western countries and demonstrated the catastrophic effect that depleting resources might have. The fact that this led to short-term record food and fuel prices, while raising concerns about the longer term impacts on food security, migration, civil unrest and uneven development, raises its significance further.

Although the cost of oil fell dramatically to less than \$50/barrel in April 2009, it has subsequently risen steadily to around \$75/barrel. National and international economies are also facing pressures related to the economic recession, and hence issues of global resources and sustainability remain paramount. Tackling climate and environmental change is perhaps the greatest issue of our time but has often been eclipsed by more local and short-term issues. Climate change and in particular peak oil still seem to be underestimated in many areas of the developing world, where modernisation and wealth have greater primacy. While

modernisation can bring opportunities for local wealth, employment and material goods, it places increasing demands on scarce global resources through changing consumption habits and irreversible changes to land use (e.g. urbanisation and loss of farming land). Thus, as developing countries aspire to become more like those in the west, use of the world's resources increases further. It has been estimated that extrapolating current (western) industrial consumption and production patterns to the entire world would require ten times the existing resources (Carley and Spapens, 1998).

In addition, political commitments towards climate change and sustainability change over time and have recently been eclipsed by the dramatic changes occurring in the global economy. Yet the cost to the global economy of inaction is colossal – a cost Jowitt and Wintour (2008) estimate to be in the region of 5–20% of GDP (gross domestic product) against a planned programme of action costing around 2% of GDP (Stern, 2007). As a result, there is still a noticeable difficulty in garnering support for sustainability in some parts of the world, while more needs to be communicated on good practice (Filho, 2000).

Previously, good practice measures have comprised investment in greater resources (including technology) to reverse and alleviate the effects of climate change, as well as cultural or educational approaches to curb increases in consumption of scarce resources. This paper presents a third arm in the debate, which might also be described as cultural in as much as it relates to a change in behavioural approach, but is still strongly aligned to policy and governance. The paper draws extensively on the policy changes implemented as a response to Cuba's special period, which entailed changes to the urban planning regime, stringent changes in cultural attitudes to use of resources and investment in alternative approaches such as renewable energy and agriculture. While initially Cuba's response was based on that of survival in the face of collapsed international trading, over time this has led to genuine sustainability and resource prosperity. Although the circumstances leading up to the Cuban special period are politically complex and abrupt, with so few examples available worldwide and given that peak oil may be imminent if not already be upon us (Hopkins, 2008; Lerch, 2007), much can be garnered from Cuba as a primary case study.

2. CUBA: AN INSIGHT INTO SUSTAINABLE DEVELOPMENT

'Peak oil' or 'global peak' is the point at which we have extracted

half of the oil that has ever existed – the half that was most accessible, easiest to refine and of the highest quality. What is left is located in places that are not easily accessible and in forms difficult to refine (e.g. not in liquid form), meaning that the half that is left is uncertain and may not be economically accessible at all. Hubbert (1956) expressed these concerns in terms of a geological limit to the supply of oil – peak oil – with ‘peak’ inferring that the world would subsequently enter an irreversible arc of depletion. The world oil peak therefore represents an unprecedented crisis that some believe will wreak havoc (Kunstler, 2006) or, at the very least, will undoubtedly present unprecedented challenges to civilised life that as yet we are unable to imagine.

Cuba, having endured a simulated (although abrupt and imposed) peak oil period following the collapse of the Soviet Union, provides an approximation of what impacts may be felt at local and national level in terms of loss of energy. Necessitating special measures to prevent extensive starvation and loss of life following the collapse of international trading of not only important energy supplies but also important staples, this is known as the special period in Cuba.

Starting with the revolutions in Czechoslovakia, Poland and Bulgaria in 1989, the Communist party’s decision to give up its monopoly of power in Russia in February 1990 set in train a series of events that would lead to dissolution of the Soviet Union and the severing of important supply lines to countries such as Cuba (Cuba had become reliant on Soviet imports such as oil reserves, machinery and foodstuffs for the day-to-day functioning of towns and cities following the 1959 Cuban revolution and subsequent US trade embargo). The initial disruption and dislocation of important supplies quickly gave way to cessation from the Soviet Union, creating an immediate halving of overall oil imports and quickly destabilising Cuba’s energy system. As the once 24 h energy system was reduced to just a few hours a day, industry, agriculture, transport and

commerce ceased to operate effectively. The urban areas of Cuba, which housed around three quarters of the population, were effectively brought to a standstill. Places of work ceased to operate without power, the transport system was overwhelmed and the shortage of food created the type of fear akin to a country at war. Calorie intake fell sharply by 30% (Funes, 2001) and Cubans faced starvation; cases of malnutrition leading to blindness and anaemia in pregnant women were prevalent.

While it is true that in the two decades since the collapse of the Soviet Union Cuba’s scarcity of resources has been met partially through other former client states of the Soviet Union such as Venezuela, the way that Cuba responded initially to the crisis through strategy and policy adjustments makes Cuba exemplary from a policy perspective. The fact that Cuba now boasts such favourable human development in areas of health and education and exhibits marked levels of sustainability (wealth and standard of living as a proportion of used resources) suggests that Cuba is now unrivalled as a world case study.

As Table 1 shows, while Cuba still languishes in terms of economic prosperity with per capita wealth of just \$125 (low even in a developing world context), it exhibits above-average human development (ranked 48th out of 157 countries with a human development index of 0.855) and excellent sustainability credentials measured in terms of wellbeing (mental capital, life satisfaction) as a proportion of resources used (being ranked 7th out of 143 countries with a happiness index of 65.7) (NEF, 2009; UNDP, 2008; World Bank, 2009). Cuba’s strong social development credentials are remarkable since they run counter to the wider correlation usually found between financial wealth and human development ($r^2 = 0.914$), while its strong socio-environmental performance reflects its exemplary policy achievements as a result of the special period. The key policy areas contributing to this social and environmental development are now examined individually.

Country	Wealth (PPP*): US\$ billion (rank/178 countries)	Human development index (rank/157 countries)	Happiness index (rank/143 countries)
Cuba	125 (157)	0.855 (48)	65.7 (7)
USA	14204 (1)	0.950 (15)	30.7 (114)
UK	2176 (7)	0.947 (21)	43.3 (74)
Argentina	571 (22)	0.860 (46)	59.0 (15)
Australia	762 (18)	0.965 (4)	36.6 (102)
Brazil	1976 (9)	0.807 (70)	61.0 (9)
Canada	1213 (14)	0.967(3)	39.4 (89)
China	7903 (2)	0.762 (94)	57.1 (20)
France	2112 (8)	0.955 (11)	43.9 (71)
Germany	2925 (5)	0.935 (23)	48.1 (51)
India	3388 (4)	0.619 (132)	53.0 (35)
Indonesia	907 (16)	0.728 (109)	58.9 (6)
Italy	1840 (9)	0.941 (19)	44.0 (69)
Japan	4354 (3)	0.953 (8)	43.3 (75)
Mexico	1541 (11)	0.829 (51)	55.6 (23)
Russia	2288 (6)	0.802 (73)	34.5 (108)
Saudi Arabia	589 (21)	0.812 (55)	59.7 (13)
South Africa	492 (22)	0.674 (125)	29.7 (118)
South Korea	1358 (13)	0.921 (25)	44.4 (68)
Turkey	1021 (15)	0.775 (76)	41.7 (83)

*Purchasing power parity – using nominal prices adjusted for price differences between countries

Table 1. Performance of Cuba in an international context (G20 group) (NEF, 2009; UNDP, 2008; World Bank, 2009)

2.1. Cuban transport policy

Since oil remains the predominant fuel source for transportation (Lerch, 2007), Cuba's 70% decline in oil imports during the 1990s to around four million barrels per year as a result of the collapse in international trading (CS, 2006) had an immediate and catastrophic impact on Cuban's day-to-day mobility and the functioning of urban areas. At the time, many Cubans still relied extensively on personal transport; the fuel shortages were thus felt acutely by the public transport system, which became crippled by the twin effects of both the reduction in oil and the increased demand for buses in lieu of private car use. Simple tasks such as commuting to work became arduous, time-consuming and costly as bus services became unreliable (from disruptions in fuel supplies) and buses became severely overcrowded. Typically, workers took 3–4 h to travel across the city only to find their place of work without electricity for hours at a time and facing the prospect of a long and difficult journey home. With a population of around two million people, the economic impact of such cessation of economic activity in Havana at this time would not be very different to the loss of Birmingham, Manchester or Leeds from the UK national economy.

Transportation difficulties also affected the production and delivery of food to Cuba's urban population, some three quarters of the population at this time (Perez, 2008). Similarly, access to front line services such as education and health became threatened.

The solutions to the transportation crisis were numerous and varied. As a short-term measure, Cuba imported 1.2 million bicycles from China and produced 500 000 more (CS, 2006); 250 000 were introduced in Havana alone (Perez, 2008). This enabled key professionals such as doctors and teachers to travel to their places of work and maintain key services. Public transport was also improved substantially through investment in alternative transport models designed to maximise users while minimising fuel usage. For example, 'camel transporters' and 'truck buses' were designed to transport up to 300 people at a time and trucks were converted into buses to enable mass transport in urban communities (Figures 1 and 2).

The introduction of new modes of transport was supplemented by legislative measures. For example, it became compulsory for



Figure 1. Cuban camel/truck bus



Figure 2. Inside a Cuban truck bus

government vehicles to pick up anyone who signalled they needed a lift in order to maximise use of vehicles and multi-share taxis were introduced in urban areas (along with horse and cart in rural areas). These transport measures were complemented by 'relocalisation' as a key plank of Cuba's spatial planning policy, with a view to easing mobility in large urban areas and facilitating the re-functioning of the economy. Relocalisation strategies are premised on more localised social and economic activity to reduce complex travel and commuting patterns, and are recognisable as:

- reversal of spatial division of labour – where areas were previously specialised to achieve economies of scale
- dispersal of urban activities – a reversal of urbanisation and the breaking-up of large urban agglomerations
- decentralisation of services to outlying areas.

In Cuba, relocalisation was achieved principally through the extensive decentralisation of key services such as education and health. Where previously universities were concentrated in key specialist areas such as the old quarter in Havana, higher education facilities can now be found in each of Cuba's 169 municipalities. This same decentralisation has been achieved in the health sector, with doctors and other health professionals effectively 'living in the communities they serve' with a ratio of around one doctor per 176 inhabitants (Perez, 2008). While undoubtedly this has contributed to the high social development of Cuba as recognised in Table 1, it has also enabled extensive front line services to be provided to Cubans without incurring further consumption of resources through personal travel.

In addition to the decentralisation of public services, Cuba has sought to relocalise socio-economic activity to suburbs/smaller communities by promoting 'local workplaces' and encouraging the development of local amenities through dispersed and more equitable distribution of resources. This means that local residents can access key amenities by walking or cycling to local points in their community, which previously would have required the use of cars or public transport to travel across the city or to a neighbouring suburb.

2.2. Food and agriculture

The special period brought about an immediate loss of vital food imports, thus necessitating stringent changes to the production and consumption of food on the island. Cuba's approach to increasing domestic food production and bold plans for

widespread and organic farming have been much admired in recent years and have drawn international recognition. For example, in 1999, the Cuban Farming Association (Grupo de Agricultura Organica (GAO)) – at the forefront of Cuba's transition from industrial to organic agriculture and bringing together farmers, farm managers, field experts, researchers and government officials – was awarded the 'alternative Nobel prize' for its work in organic farming.

To achieve greater food security and agricultural sustainability, Cuba employed a number of measures to stimulate greater agricultural production across the island and to modify the agricultural models in use towards more organic (post-productivist) approaches, including land management, organic agriculture and urban agriculture. Post-productivist approaches are characterised by the withdrawal of competitive mass production of food towards an emphasis on quality of food (e.g. the organic movement), the culture of food (e.g. the slow movement) and the introduction of more sustainable methods (e.g. through permaculture and measures against eutrophication).

2.2.1. Land management. Since urban populations look to the countryside for food provision, the task of feeding Cuba's urban population was of grave concern to the organisation of the country as a whole. One significant reform aimed at increasing food production occurred in 1993, when Cuba turned 60% of its state farms into smaller worker-owned collectives. When the land was still legally owned by the state, it was given in perpetuity to the workers to farm and manage. In return for providing a portion of the harvest to the government as payment for the land, collectives could use surplus for personal consumption or sale on the open market. The introduction of such incentives appears to have played a significant role in driving people to work in agriculture and the production of greater yields. Within 12 months, 121 farmers' markets had opened around the island (Murphy, 1999) for the sale of food surpluses and around 400 000 new jobs had been created (FRT, 2008). At the same time, wages, incentives and working conditions for agricultural workers increased. In urban agriculture, in particular, workers are one of the top earning professions, indirectly contributing to the revaluing of agriculture and related professions in Cuban society (Wright, 2008).

Such accounts stand in marked contrast to the situation in other parts of the world, where agricultural workers are among the least well paid in society. Consequently, these reforms have not only led to improved food security (land productivity is greater than in state-owned farms (Emmet and Hickman, 2007)) but they have also provided significant employment opportunities.

Collectives have also been noted as being more energy efficient, since larger farms have greater dependency on oil for the transport of labour and operation of machinery than the use of oxen and manpower in small collectives (Table 2). The use of oxen provides additional environmental benefits: they reduce soil compaction and erosion, which has been reported to have had 'a positive effect in reducing degradation of hillsides' and is more viable during the rainy season when tractors bog down in mud (Rosset and Medea, 1994).

2.2.2. Organic agriculture. Organic agriculture is based on crop rotation, green manure, compost, biological pest control and mechanical cultivation to maintain soil productivity and pest control; it excludes or limits the use of synthetic fertilisers, pesticides, food additives and genetically modified organisms (EU, 2008). Organic agriculture accounts for 90% of agricultural production in Cuba, with many different agricultural systems being employed to suit local soils, climates and urban/rural settings. Natural inputs for fertilisers and pest control (bio-fertilisers and bio-pesticides) that are made widely available to producers and are cheaper than purchasing chemicals on the global market have been developed. Techniques such as 'interplanting' (planting more than two crops in fields to maximise production and protect the soil), crop rotation, insect traps and the planting and application of botanical pesticides are also used to reduce crop susceptibility to pest problems. Developments in organic agriculture and the exchange of best practice between local communities have been important in reducing over-cultivation of land, overuse of fertilisers and pesticides, protecting water courses and the mainstreaming of organic methods – even to areas previously perceived as infertile and non-arable (FRT, 2008).

2.2.3. Urban agriculture. As mentioned earlier, Cuba's urban population accounts for three quarters of the total population. The ensuing food crisis during the special period was thus felt most acutely in urban areas where there was a reliance on food being imported from the countryside. However, the lack of transport to distribute what little produce there was available to towns and cities in addition to greater food rationing meant that people instinctively began to grow their own food (Mark, 2007). What started initially on domestic/residential rooftops and balconies quickly took off and enveloped unused spaces such as old parking lots or derelict land. As the authorities saw the success of these developments in meeting food needs they enacted institutional changes to place more land into the control of communities and to incentivise private enterprise in food production. Such developments have led to a significant variety of urban agricultural settings and forms, and a greater number and range of vending outlets for agricultural produce such as street markets (Figure 3).

Tilling unit	Required hours	Energy input: kcal				Total
		Machinery	Petroleum	Manpower	Oxen power	
Manpower	400	6000	0	194000	—	200000
Oxen	65	6000	0	31525	260000	297525
6 hp tractor	25	191631	237562	12125	—	441318
50 hp tractor	4	245288	306303	2400	—	553991

Table 2. Comparison of energy inputs for tilling methods (Pimentel and Marcia, 1979: p. 1227)



Figure 3. Street corner vending outlets, Havana © E. Piercy

Other developments included the formation of a ministerial department devoted to urban agriculture. This provides outreach workers to support new community gardeners, seed shops to supply seeds, and the provision of tools and bio-products, which have led to a new urban gardening movement. Urban gardens now produce the majority of the fruit and vegetable requirements of urban areas (60% in Havana) and in some areas surpluses are sold for wider consumption, with a third of all vegetables now being produced for export (Wolfe, 2004). The speed at which 'local food production' has been established lies as much in the ability of households to meet their own consumption requirements as it does in increasing the freshness of food consumed while reducing miles associated with food delivery.

From a social perspective, it could be argued that urban agriculture has led to a strengthening of community cohesion, a point raised by several stakeholders (e.g. CS, 2006) but one that has hitherto not been researched. It is a reasonable supposition that being involved in food and local agriculture not only brings personal benefits but also brings rewards by enhancing the lives of others in communities. In participating in the 'war against hunger', individuals are also recognised as fulfilling not only a personal function but also a social one in helping to achieve food sovereignty for all. Community gardens have become key points of transaction in the community, bringing together the young and old and different professional groups, and it is conceivable that they have thus engendered more cohesive communities.

Urban agriculture has also been found to enhance the visual imagery of urban areas by 'softening the harshness of the city landscape' (Funes *et al.*, 2001). The development of green spaces conveys a city that is 'closer to nature' (Cruz and Medina, 2001), enhances biodiversity and makes significant functional and visual contributions (having a cooling function during sustained periods of hot weather while improving aesthetics).

In looking at urban agriculture as a whole, not only does it contribute much towards reducing the ecological footprint and environmental space associated with urban areas, but it also adds to the economic and social development of communities. It is a testament to the success of Cuban land reforms and agricultural policies that Cuba's calorie intake now stands at the

pre-special period level and 'in a sign of restored prosperity, some Cubans are beginning to worry about obesity' (Mark, 2007). Furthermore, the use of pesticides has dropped 20 fold since 1989 (Stricker, 2007): where once Cuba used more than a million tonnes of synthetic fertilisers a year, today it uses around 90 000 t (Mark, 2007).

2.3. Electricity generation and consumption

One of the most prolonged effects of Cuba's oil import collapse was long-term disruption to the national energy system, most notably the electricity and gas supply, which initially created power blackouts up to 16 h a day. Scheduled rolling blackouts of several days per week lasted for many years, destabilising industry and disrupting households that had come to rely on energy consumption for material goods such as televisions and for coping with life in a tropical climate (e.g. cooling systems in residential blocks, refrigeration). The response has largely been one of adaptation.

Over time and with Venezuelan support, the Cuban government developed a long-term comprehensive national energy plan that promotes and balances three key factors: economic growth, energy conservation and protection of the environment (Pinon, 2005). The plan has brought many energy-related developments to the island.

Cuba has invested in replacing its ageing Russian oil plants with gas-fired combined cycle turbines that, although expensive, are cleaner and more efficient. Decentralised deployment has also promoted greater security and continuity in energy supply. Cuba's largest risk comes from natural disasters arising from hurricanes; the previous design of centralised energy provision compromised energy supplies throughout the entire island whenever hurricanes hit. A more decentralised system helps to build resilience by ensuring that only one or two sub-systems are hit at any one time.

This is illustrated by the impact of two hurricanes on the Cuban territory over two weeks in August/September 2008 when more than 130 transmission line towers were destroyed in the western province of Pinar del Río. Distribution lines in the eastern part of the country and the centralised power station located in Nuevitás, north of Camaguey province, also suffered tremendous damage. Although the magnitude of the disaster created by the hurricanes was compared to that of a bomb, the existence of decentralised energy systems ensured that critical energy and water supplies were maintained (Alberto, 2008). After the hurricanes, diesel gensets were situated in specific places, creating micro-electrical systems to guarantee services to the population (Alberto, 2008).

At the same time, the renewable energy industry in Cuba has undergone substantial development. Although biomass generated by the sugar industry accounts for up to 40% of the country's electricity requirements during harvest time (CS, 2006), other renewable applications are focused on smaller scale opportunities in solar, hydro and wind power, with solar water heaters proving popular. As Alberto (2008) indicates, 'renewables' and other decentralised forms of energy generation now contribute in excess of 40% of electricity generation in Cuba – a position that rivals the very best sustainable systems worldwide.

Energy conservation has also played a significant role in achieving more reliable energy supplies by reducing overall demand. The most famous initiative was the whole scale replacement of incandescent light bulbs for energy-efficient ones. Almost 15 million incandescent bulbs have now been replaced (CubaSi, 2009), enabling Cuba to be the first country in the world to phase out inefficient lighting. Another incentive for energy efficiency in the home is a range of domestic fuel saving devices that have been made available at low cost to all families (Whittle, 2007). This has been made possible to some extent by the implementation of simultaneous restrictions on the sale of non-essential household electrical items, which have only recently been eased as Cuba's energy situation has improved.

A key element in the success of these energy efficiency measures has been the cultural change taking place amidst public awareness of sustainability issues. As noted by Quinn (2006), education is 'the most important social activity in Cuba' and energy education for all schoolchildren, which began in the 1970s through community-level 'click patrols' and curriculum development, has been pivotal in changing attitudes to energy saving in the home (Alberto, 2008). Beyond education, a weekly programme on energy issues is broadcast on national television to facilitate shifts in cultural attitudes towards energy use, and billboards promoting energy conservation are scattered across the country (Alberto, 2008). Implicit is the recognition that reduction in demand for resources is one of the most cost-effective and long-lasting approaches to achieving sustainability.

A further element to reducing energy consumption has been through the introduction of bioclimatic architecture design principles that have been integrated into new-build schemes. Projects range from the use of natural ventilation to avoid dependence on energy-intensive mechanical systems to the incorporation of straw bale construction to reduce the use of energy-intensive concrete (Lippman *et al.*, 1997). Additionally, the production of ecology-friendly materials for the construction of houses has also now been extended to 38 Cuban municipalities. Prefabricated roof and wall parts for some 11 000 houses each year are also being produced in several provinces, using local materials and labour. In 2007, the Cuban research centre working on these projects (Centre for the Development of Materials and Structures) was awarded the United Nations' Habitat World Prize in recognition of its promotion of ecology-friendly materials.

3. CONCLUSIONS

Cuba has overcome the economic and social crisis brought about by the collapse of the Soviet Union through a series of policy measures based around relocalisation of key public activities, adjustments to agricultural production and consumption, and strategic change concerning renewable energy. These measures have enabled the country to dramatically reduce resource consumption and attain higher productivity from their resources, while still advancing the country's social, economic and environmental wellbeing. Three key socio-political factors have underpinned Cuba's strategic response to the special period.

(a) The political system in Cuba – an autocratic system based on socialist ideology – can be argued to have created and

supported the political will and vision needed for radical structural changes to be envisaged and realised.

- (b) The personal risks and difficulties experienced at individual and household level from the loss of everyday commodities such as food and key services created sufficient incentive for people to accept and implement radical changes.
- (c) The culture and recent history of participative democracy found throughout Cuba in every local community was instrumental in galvanising local action and permitting changes to take hold in communities.

While it is important to recognise the role of these three factors in driving policy adjustments and ultimately contributing to their success, it could also be argued that these have also created conditions that have prevented this research from going further.

In many respects, this paper raises more questions than it does answers. On the issue of how well the system is faring amidst a global economic downturn, there is evidence that its progress has been militated by the current global economic crisis, critical challenges in the form of the hurricanes in 2009 (the worst in 50 years) and the continued US embargo. During 2009 and 2010, factories have closed, food rations have been reduced, fuel for transport has been in short supply and there have been signs of disruptions in electricity supply.

In response, the government has introduced an austerity programme to offset the impact of the financial crisis and to reduce energy use further. The global crisis thus seems to be affecting Cuba as much as other countries (Benini, 2009) but the situation is not as fragile as it was in the 1990s. There have recently been calls for greater agricultural reform and debate continues as to what is an appropriate balance between state and free-market approaches (creating a space for re-rehearsing ongoing debates highlighted by Marshall (1998) and Cardoso and Helwege (1992)) and how future crises can be overcome through community action and local political will (Perez, 2008). Seemingly, Cubans are used to adversity and experience is on their side to help them overcome these difficult times – they see human relationships rather than technology as key to achieving long-term success (CS, 2006).

Regarding the measures implemented (decentralisation of key services, for example), it would be interesting to know what planning policies were implemented to realise such a national strategy – whether new buildings were constructed or existing ones were requisitioned and modified – and what spatial impacts this has today in terms of demographic growth of outlying areas and communities, changes in travel use, urban pollution, etc. While it is possible to conceive that relocalisation and decentralisation of key services and activities might manifest as something akin to polycentric urban systems (which are spatially proximate but functionally separate local urban centres; see Parr (2004) for a broader discussion), it is not possible to acquire the type of data needed to make a before-and-after empirical analysis in this paper. The same appears to be true for Cuba's agricultural policy adjustments, the organic and urban agriculture movement and the energy plan, much of which have received international acclaim in recent years. Researchers are limited to the information provided by an autocratic system; while what has been provided has yielded

fresh insights and much interest, it is acknowledged that it lacks the type of critical rigour found in other studies.

What has been presented here is not a comprehensive and definitive picture and does not purport to be. It does, however, point at a viable model in the face of the unknown and what has been referred to as an impending catastrophe, and therefore creates a space for important debate. As Kunstler (2006: p. 3) notes:

[the Western world] can only run on reliable supplies of oil and gas – mild to moderate deviations in price and supply can crush our economy and make the logistics of daily life impossible.

Therefore, empirical insights – no matter how partial – provide important insights into a potential post-carbon world in a way that helps to prepare and plan for inevitable changes. Thus far, the western world has been grappling with ways to incorporate environmental, economic and social sustainability within new developments, including the design of 'eco-towns', greening of cities through green roofs for example, energy reduction through biomass developments (e.g. LEED platinum schemes in North America) and the widespread planting of edible landscapes and allotments (e.g. South East False Creek in Vancouver). Yet many of these have been developed in isolation. Even where more holistic approaches have been attempted (e.g. Amersfoort in the Netherlands and Dongtan in China), they have been restricted to one city or area. What has been done in Cuba is impressive not only in terms of bold and imaginative rescaling and reorganising of society and the economy, but also in the scale and systemic approach adopted. While relocating economic activity has been effective most notably in Havana, it has impacted on all areas of the island through new service provision.

While the true impact of localisation is still to some extent unknown, it could be regarded as a desirable organising framework since it eradicates 'diseconomies of urban size such as congestion and pollutions' (Parr, 2004) while also promoting a more equitable use of resources. The Cuban model therefore points to a possible plan or approach for dealing with peak oil in a way that has not been possible to glean from small case studies elsewhere such as transition towns and more local initiatives (Hopkins, 2008). Cuba therefore has much to offer due to its sheer scale and the holistic approach in which the country's sustainability was approached as a system – an approach Brown (2007) sees as pivotal to the planning of post-carbon spaces over the coming years. Indeed it has been said 'Cubans have created a working model for the future that we all face' (Don, 2008).

Although this sustainable approach was implemented throughout Cuba, including rural areas, the scale of change implemented in Havana and Santiago de Cuba as the country's key urban areas provides valuable insights into ways of redressing heightened energy consumption and greenhouse gas emissions now occurring in many countries and particularly in the world's largest cities. This is particularly important given that cities worldwide consume around three quarters of the world's energy and produce 80% of greenhouse gas emissions (CFCI, 2008), highlighting the precarious relationship between the continued pace of global urbanism and accelerated urban growth and resource use. Therefore, despite the Cuban situation being

politically different from other countries and the loss of resources more abrupt and unplanned, it is argued that there is still considerable scope for wider application of the Cuban concepts to other towns and cities, if not countries and cultures.

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