2 Resource Depletion

Online student resources

Additional materials

Urbanisation and the ecological imperative

2009 was the first year in the history of humankind that more than fifty percent of the world's population lived in a city as opposed to an area classified as countryside. Given the radical difference between the structural circumstances defining urban vs. rural lifestyles, there is little question that this demographic change will affect the ecological imperative formulated throughout this book in resource depletion or pollution terms. The question is whether the trend towards a less agricultural existence has purely negative consequences as seems intuitively likely, or whether there are also arguments sustaining the opposite viewpoint.

The background to this debate is the decades if not centuries long migratory pattern of populations flocking to cities and abandoning the rural settings that once hosted the vast majority of human settlements. Over the years, this trend has had a host of drivers: technological progress enabling increasing amounts of food to be produced using less labour; a combination of population growth and inadequate inheritance regimes, culminating in working forms being subdivided over the generations until plots grow so small that they were no longer economic; industrial goods' rising relative price; and the attraction of higher paid jobs in the city. Add to this the fear that climate change will lead to a further displacement of isolated rural populations (Traynor 2008) lacking the state support systems that can only be delivered effectively in population centres exceeding a certain critical mass and there is little prospect, at least in the short run, of this urbanisation trend abating.

The question then becomes whether the environmental footprint associated with city living is intrinsically higher than rural living. Some analysts (Owen 2009) have rejected this premise, noting for instance that a New Yorker's per capita greenhouse gas emissions are less than one-third the size of the average American's because the proximity between different destinations in Manhattan reduces overall travel needs (and because the city's higher income levels means that residents can afford energy efficiency devises). Yet a number of indicators do in fact indicate that urbanisation has a heavy footprint, starting with the phenomenon of urban sprawl that extends the periphery of many municipal regions to eat into surrounding farmlands. A prime example is China, where the need to lodge the millions of ex-farmers looking for industrial work has led millions of acres of formerly arable land being paved over – and to increased demand for energy and natural resources to operate the kind of transportation and general services that constitute an urban fabric (Devan et al 2008). According to some estimates, energy demand by municipalities in China – expected to add a total of 325 million city dwellers by 2025 – will double total national energy demand and increase the demand for water by 70 to 100 percent.

A second consideration is that urban incomes are on average significantly higher than their rural equivalent, leading as often as not to a greater consumption of resources. Otherwise, with respect to the ecological imperative's pollution aspect, "Because of effects of traffic congestion, concentration of industry, and inadquate waste disposal systems, environmental contamination is generally higher in cities than in countryside and often in excess of local government's ability to assimilate waste" (Bloom and Khanna 2007). One shocking estimate is that as much as 10 percent of total land area in American cities is devoted nowadays to car parks, spaces that cause major environment damage due to the runoff of heavy metals, pesticides, bacteria and industrial pollution and because they encourage further urban sprawl, create heat islands and reduce biodiversity (Harris 2009). A few efforts are being made to ameliorate the situation by using permeable surfacing and ozone-absorbing trees but this is treating symptoms rather the disease. With few exceptions, city life has become the frontline of the battle for sustainability today. It is therefore here that some of the most significant ecological remedies must be tried.

Many of the solutions that governments and companies are developing to overcome urbanisation's green dilemma can be categorised along the sectorial lines formulated in the book's Chapter 9. A prime example is transportation, with the intensive consumption of greenhouse gas-emitting fuels by urban commuters being a leading contributor to global warming. One of the main areas of focus in this area is the general effort to get people out of passenger vehicles (via congestion charges, road tax measures or parking restrictions, etc.) and into public transportation modes whose environmental footprint per kilometre travelled is infinitely smaller than private modes. To achieve this, municipalities everywhere have been working to make their mass transit systems more attractive both financially (by subsidising fares) and physically (through friendlier and safer travelling conditions). They have also been trying to make them more convenient, largely through the coordination of intermodal hubs that facilitate passenger transfers between different urban and suburban systems. Most if not all of the world's major cities feature signature programmes in this area. Some - often emerging economy cities such as Bangkok or New Delhi lacking a mass transit network – involve 'big-bang civil engineering projects' (Sloman 2006). Other simply nudge people into 'demotorisation' by making greener alternatives seem more tempting. This can revolve around the creation of fast routes allowing extra large buses to whisk commuters quickly to their destination (an approach pursued in a number of South American cities) or else something as simple as the extension of bicycle hire schemes. There are similar efforts aimed at reducing existing systems' footprint, exemplified by the many cities worldwide that are trying to organise bus fleets that emit little or zero carbon.

Where possible, urban planners have also been working at a more structural level to design spaces in such a way that less energy needs to be consumed in the first place. Firstly, there is a well-established policy nowadays of reclaiming former industrial spaces located within a city's confines to avoid expansion along its periphery (Guevarra 2008). Such brownfield 'urban infill' intensifies the use of existing traffic infrastructure and reduces the overall distances that people or companies must travel. Secondly, there is the creation of holistic neighbourhoods where residential, commercial and leisure facilities are situated in close proximity to one another, with famous examples including the Roppogi district in Tokyo and above all Vauban near Freiburg in Southwest Germany. Note that this organisation contrasts directly with the district specialisation that is one consequence of centuries during which urban land use has been dictated by zonal price differentials to the detriment of any other consideration. To some extent, what is happening here is that actors in the city are deciding that adherence to sustainability takes priority over purely finanical determinants of land use.

The same can be said about the evolving relationship between cities and the surrounding areas that provide them with the raw materials they consume. Whereas cities have traditionally relied heavily on their 'hinterland', the idea now is that they should become more self-sufficient. On one hand, there have been noted efforts in recent years to get cities to produce more of the energy that they consume through the implementation of small-scale renewable energy projects. Similarly, a great deal of work has been done to modify cityscapes and buildings using trees and other fauna together with rainwater harvesting and other green construction techniques (see Chapter 9) that reduce the need for building materials or water resources. Above all, there is the growing trend towards urban farming or at least towards having an urban society source a greater percentage of foodstuffs from its immediate vicinity. This is the logic underlying the famous Green Belt surrounding London, which despite developers' best efforts to erect out-of-town shopping centres – a particularly unsustainable form of urban living - has been more or less protected from non-agricultural encroachment for more than a century now. At the same time, in mega-cities lacking similar legal protections (often located in the developing world but also in countries such as the United States where planning restrictions tend to be comparatively lax) , it is financially tempting to build new developments precisely on the outskirts of a town since land is cheaper here. This reduces the amount of farmland being tilled in proximity to urban consumers, a real problem if areas beyond this zone are not particularly fertile. For instance, Cairo's expansion into the best Nile farmlands means that Egypt must now replace this natural resource by irrigating less fertile deserts. It is one thing to advocate sustainable cities but quite another to actually implement them.

Hence the growing sense that cities (or more precisely, municipal regions) will only be able to face up to the ecological imperative if efforts are also made to raise citizens' consciousness to the extent that they modify their conceptions of self-interest to incorporate notions of sustainability and group interest. This is the idea underlying the rise of the 'Transition Town' movement where citizens are expected to get together regularly to train one another in reducing their environmental footprint (Keegan 2010). The idea here is that cities become sustainable when enough residents adopt micro-behaviours that promote localism and recycling. Leading examples include towns such as Montpelier in the US state of Vermont where there has been great emphasis on renewable energy sources and 'permaculture' food systems requiring little oil or electricity. The fundamental philosophy here or in other Transition Towns (like a famously active body operating in Belsize Park, London) is that communities imbued with a sense of cohesion will be more apt to devise lifestyle solutions enabling them to show 'resilience' in the face of resource depletion and other environmental problems. In this view, urban sustainbility is as much a question of attitude as action.

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Biomass

A concise source of information on the science underlying this particular source of natural energy is the Biomass Energy Centre (BEC), part of the research wing of the UK Forestry Commission. The website developed by this body (www.biomassenergycentre.org.uk) offers a systematic illustration of how fuel category originates and is processed and used, starting with a chemical definition of biomass as a carbon-based "mixture of organic molecules containing hydrogen, usually including atoms of oxygen, often nitrogen and also small quantities of other atoms, including alkali, alkaline earth and heavy metals". In more functional terms and as indicated in Chapter 1, "The carbon used to construct biomass is absorbed from the atmosphere as carbon dioxide (CO_2) by plant life, using energy from the sun". In turn, when plant materials come to the end of their useful life, decomposition often leads to carbon being returned to the atmosphere, mainly in the shape of carbon dioxide (CO_2) but also as methane (CH_4). This so-called carbon cycle has always been the key feature of life on Earth.

At one level, the only difference between conventional fossil fuels and biomass is the time scale over which they develop. Fossil fuels are little more than biomass that has accumulated underground over eons under specific conditions lending themselves to the energy content being trapped. This is the concept of 'ancient sunlight' that is also explored in Chapter 1. Note that fossil fuels' energy density is generally much more concentrated than simple biomass, due in part to the moisture levels. This explains the general preference for fossil fuels. The problem is that their global dispersion is very uneven. Above all, modern economies consume them much more quickly than they are being constituted through their millennial trapped decomposition processes. The end result is that these pools of concentrated energy are being depleted. Conversely, there is growing focus on the possibilities afforded by recently produced biomass that – if only because it exists above ground – is easier to monitor and above all to access.

The BEC website divides biomass materials into five categories whose desirability as an energy source depends on a host of factors, first and foremost being their value in their original form compared with the amount of energy they might generate in biomass or biofuel form. The five basic categories are:

- "**Virgin wood**, from forestry, arboricultural activities or from wood processing
- **Energy crops**: high yield crops grown specifically for energy applications
- **Agricultural residues**: residues from agriculture harvesting or processing
- **Food waste**, from food and drink manufacture, preparation and processing, and post-consumer waste
- **Industrial waste and co-products** from manufacturing and industrial processes".

Each kind of biomass is converted to a useful and convenient energy application using a variety of technologies. Timber, for instance, will often have to dried or cleaned before being burned as woodchips in biomass boilers or other heating processes. As Chapter 9 states, a growing number of agricultural crops are grown nowadays specifically for use as ethanol-based "biofuels". This can involve a whole range of short rotation vegetables, leading to concerns about the growing tendency to dig up heretofore untilled farmlands to find space to plant the new energy crops, an action that releases dormant carbon while diminishing the overall space left to grow food crops. For this reason, agricultural residues (and composted 'food waste) can be viewed as more environmentally-friendly sources of biofuels, since both are based on reducing waste and not on expanding current cultivation areas (thus using more fertiliser, etc.). The same applies to the organic waste byproducts of certain industrial activities.

Despite concern about the diversion of crops to biofuels at a time of global food shortages, many governments have developed policies encouraging the use of biomass as an energy source, if only because of concerns about the rate at which fossil fuels are depleting. In truth, many households in the world's poorer countries, particularly in Africa, South Asia and Southeast Asia, have never stopped relying on biomass as a primary energy source for basic uses such as cooking or heating – to the extent that biomass constitutes a defined category in International Energy Agency (IEA) statistics on global primary energy supplies. Figures for recent years (http://www.iea.org/textbase/nppdf/free/2010/key_stats_2010.pdf) indicate, for instance, that "combustible renewables and waste" accounted for 10.6% of total global primary energy supplies in 1973 versus 10.0% in 2008. The slight fall, attributable to a greater use of fossil fuels by the world's poorer nations over this period of time, can be contrasted with the rise experienced in the older industrialised countries, where the category rose over the same period from 2.3% to 4.4% due to the proactive development of biomass-based energy. At the same time, it is worth noting that this source accounts for a much smaller percentage of the world's electricity generation, representing 0.6% only in 1973 and 2.8% in 2008, despite being included in the same category as geothermal, solar and wind energy. In other words, very little of the biomass currently being cultivated for energy purposes is being introduced into the pools of energy commonly used to sustain national electricity grids. Instead, the main applications are, as aforementioned, for direct combustion by poor households (with the ensuing local smog problems) and, in countries like Brazil, fuel for automobiles.

Related websites:

www.aebiom.org (European Biomass Association)

www.biofuelswatch.com/

www.eubia.org/ (European Biomass Industry Association)

www.guardian.co.uk/environment/biomass-and-bioenergy

Revision tips

- In the absence of a 'closed loop' production system that has been ecologically optimised so that companies' outputs become inputs used in subsequent manufacturing cycles, resource acquisition is the first step in any economic transformation activity.What counts is whether a company's competitive position allows it to access resources cheaply enough to transform them into sellable products at a profitable price. Relevant factors include whether it receives subsidies towards this end or can pass its own costs on to end users.
- In classical economics, where a company struggles to pass higher costs on to customers, this should motivate it to innovate, enhance inputs' productivity or adopt substitutes. The problem with most energy sources is a lack of substitutes. Fossile fuels (ancient sunlight) are being depleted faster than they accrue (Hubbert's concept of 'peak oil').
- Despite fuel efficiency/energy productivity improvements, the demand for energy is accelerating (up 10 percent by 2020) due to population growth, the expansion of certain energy-intensive economies, the relative inelasticity of consumption to price, "Jevon's paradox", inertia ("ostrich syndrome"), long lead times for substitute sources, etc.
- Global dispersion of traditional fuel sources aggravates distribution and explains localisation efforts including micro-generation. One issue is the proximity of main user sectors (industry, electricity, transportation) to sources.
- Oil is a key energy source (transportability, high energy density) but global reserves will be exhausted in ca. 50 years. Price should rise although they fell in 2008 due to the recession. Ironically, this diminished the motivation for conservation. Easy oil sources have already been mined and new sources are often risky or dirty.
- Gas remains popular but closely linked to oil (location and price) so it is also depleting rapidly. Coal is still the most abundant source (especially in China) but in the absence of carbon capture and storage technology it generates excessive CO_2. Nuclear is cleaner in greenhouse gas terms but expensive. Moreover, radioactive waste retains a great potential for catastrophe.
- Other economic inputs include industrial mineral resources. Theoretically these can also be depleted but timescale is counted in centuries, in part due to recyclability. The crux is the ratio between costs of new and used minerals, recycling infrastructure, etc.
- Biological resources have always been a key economic input. Leading categories include water used as cooling agent and for dilution purposes and drinking; wood, used for heating and as a material; and terrestrial and oceanic foodstuffs. Question of the incentives to steward unclaimed 'public

goods' for future consumption or else whether value should be extracted immediately – and whether resources are being exploited more quickly than their natural regeneration rate.

Online case study: Where have all the fish gone?

A number of animal species have become extinct over the year due to over-hunting by humans. Examples include passenger pigeons in the United States, Caribbean monk seals and several kinds of whales. Other species that were on the brink of extinction (Great Plains bison, primates in Africa) have only survived as a result of concerted campaigns to ensure their well-being. Now, after centuries of global over-exploitation of the seas, the question is whether the world's fishing stocks are destined to end up in the former category or the latter.

World literature is dominated by tales of times when fish were so abundant in seas or freshwater rivers that they were visible to the human eye and could be harvested without any difficulty. One consequence is that over the years, fish became a staple in many societies' diets – especially in recent decades, as knowledge of the health benefits spread. The combination of strong demand for this resource and perceptions of its inexhaustibility explain centuries of great investment in the relevant infrastructure (trawlers to capture and transport fish, facilities to prepare them for consumption, logistics to bring them to market). Of course, once so much capital and so many livelihoods are invested in an activity, downsizing it so that capacities match supply becomes economically, socially and politically difficult. Sectors tend to pursue their own growth logic, a dynamic that often neglects long-term sustainability considerations – specifically in this one case, the ecological imperative that fish species not be harvested beyond a threshold where their regeneration cycles are endangered.

Such concerns are particularly problematic with a resource such as maritime fish, found in ocean zones that (beyond internationally recognised coastal borders) do not belong to any national authority and therefore constitute a public good prone to the kind of over-exploitation that is often referred to as the 'tragedy of the commons' (see Chapter 4). It has historically been in each fishing crew's individual interest to harvest as many fish as possible yet the recurrence of such behaviour over time has had the effect of depleting most fish stocks to the point of extinction – an outcome that is clearly in the interest of neither the fishing industry nor its customers.

Evidence of the depletion of this once flourishing natural resource is ample and disturbing. After years of huge industrial trawlers sweeping through

North Atlantic (Holy 2009) or North Sea cod breeding grounds, or through the South China Sea for tuna, the situation has become so critical that the United Nations recently estimated that "up to 80% of the world's primary catch species are exploited beyond or close to their harvest capacity" (Nellemann et al 2008), with further studies estimating that at this rate, all ocean fish stocks are destined to experience a state of total collapse by the year 2048 (Worm 2006). Over-fishing is not the sole cause of this disaster, with the UN asserting that half the world catch occurs in 10 percent of the global ocean, mainly in sediment-rich waters found within 200 nautical miles of continental shores – precisely those zones that suffer most from the pollution associated with unregulated coastal development (and from the acidification of coral reefs that is one consequence of the accumulation of C02 in ocean sinks).

The sum total of these factors, along with the impoverishment of oceanic biodiversity as less hardy species become extinct and are replaced by more invasive predators, bodes poorly for the future of global stocks. In turn, this has led to an explosion in prices, with many communities famous for their fish diet – like Oma in Japan, the traditional source of Pacific bluefin tuna sold via Tokyo's Tsukiji wholesale market for use as sashimi (Fackler 2009) – no longer able to supply product affordably. Fish prices have risen at astronomical rates in just a few years, sparking an entire industry in managed fish farms that now account for up to 40 or 50 percent of many supermarkets' offer of species such as salmon. The problem is that fish farms are very crowded and therefore prone to killer viruses (like the epidemic that swept through the Chilean industry in 2009). Stocks are also commonly treated with a surfeit of antibiotics, introducing substances into the human food chain that could have negative long-term efforts. Outcomes like this show the real value of the services provided by a healthy ecosystem – and the true costs of its impoverishment.

Reactions to the overfishing crisis vary internationally. The Japanese authorities, for instance, have traditionally tended to look to market pricing as their regulatory mechanism. This does not work to everyone's satisfaction, however, with much of the international community regularly countermanding Japanese (and Norwegian) arguments to enact treaties that protect different maritime species, starting with whales (www.iwcoffice.org/). A similar situation applies with Pacific halibut, where intensified fishing techniques caused the failure of early attempts to support stock levels by shortening the fishing season, meaning that stocks were only able to replenish once the industry had agreed a strict quota system (Werbach 2009). In a similar vein, the European Union sets quotas to try to prevent regional interests – first and foremost being the Spanish float – from exploiting local stocks beyond sustainable thresholds. Unsurprisingly, there is a great deal of resistance to this kind of interventionism, the end result being that the quota reduction targets that the EU announces every year always seem less than what scientists recommend.

Whether or not the battle against fish depletion will be won remains to be seen. Recent research has indicated that anti-depletion policies have helped rebuild species such as the American plaice, pollock, haddock and Atlantic cod (Adam 2009). At the same time, North Sea, Baltic and Celtic-Biscay shelf fisheries remain in decline, with experts announcing that 63 percent of global stocks require rebuilding. Given this dire reality, it is safe to predict that fishing is one sector where resource management is destined to become a permanent fixture on the agenda.

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Case study questions

A. Why has there been such a catastrophic fall in global oceanic fish stocks?

b. Why hasn't more been done to ensure the stewardship of global fish stocks?

C. What effects has the depletion of ocean stocks had on fish markets?

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