

# Landscape urbanisation and food security

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## Abstract



This talk will explore the crucial linkages between urbanisation and food security, based on our recent and ongoing research studies. Urbanisation is often cited as one of the significant factors threatening food security. First of all, urbanisation leads to land use conversion from agricultural land to urban land use, such as for infrastructure, industrial, residential or commercial uses. Such land use conversion often reduces the most fertile land, and therefore the impact on agricultural production and food security is often larger than the absolute amount of land involved. Our recent research shows that such urban land use conversion is often driven by economic factors, with positive feedback loops between urban land use expansion and economic growth in the city, as well as in the region. In addition, urbanisation also brings about changes in dietary structure, which in turn brings about changes to peri-urban areas, where crop production is replaced by higher economic-value products such as vegetables, flowers, fish ponds, and so on. Furthermore, land use changes associated with urbanisation in developing countries are found to increase social vulnerability in the traditional farming communities in the peri-urban areas. On the other hand, some of our initial research results show that urbanisation might have some positive impacts on agricultural productivity. While all evidence seemingly points to close urban–rural linkages, research and policy approaches often treat cities and rural areas as separate sectors. Such dichotomised concepts and approaches hamper the search for an effective system-wide solution. There is a strong need to consider urban and rural areas as integral parts of a system in the global food-security debate or in urbanisation policy. The challenge then becomes to find how we can harness and maximise the positive effects that urbanisation can bring, and avoid or compensate for the negative impacts.

This paper discusses three aspects of landscape urbanisation and food security. First, it introduces some basic facts about urbanisation, which is an unprecedented transition in human settlement that we are experiencing right now. Then it reports on urbanisation impacts on agriculture, both as direct impacts on agricultural land and as indirect impacts on agriculture through various mechanisms. Third, it proposes a change in thinking, away from the current urban–rural dichotomy and towards integrated research and policy.

It is well known that more than half of the Earth's population are urban dwellers and that the proportion is increasing. United Nations projections show urban

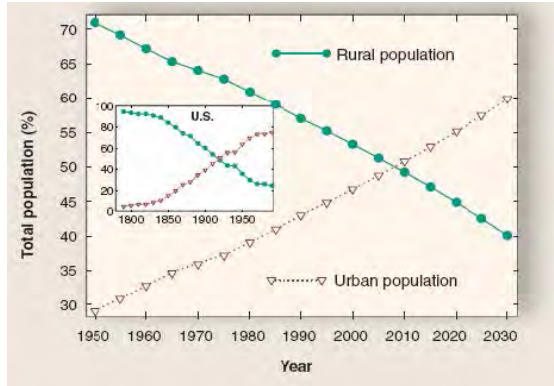


Figure 1. Urban vs rural world populations (Grimm et al. 2008).

populations growing by 1.35 billion by the year 2030, and by 2050 almost all the additional people — about two billion — are projected to live in urban areas. On that basis, the vast majority of the world’s people will be urban dwellers by 2050; see Figure 1 for example. As Klaus Töpfer<sup>1</sup> said in 2006, ‘the battle for sustainability will be won or lost in cities’.

Consider the major urban centres in the world and their growth rates. Most of the fastest growing cities are located in the developing world. During 1970–2011 in China, in India, and parts of the Middle East and South-East Asia and the sub-Saharan region of Africa, a number of cities grew at from 3% to more than 5% per year. Growth rates of up to 5% were also seen in cities across South and Central America and in some parts of USA. However, urban growth in most cities of the developed world — that is in Europe and the USSR or Russia, and

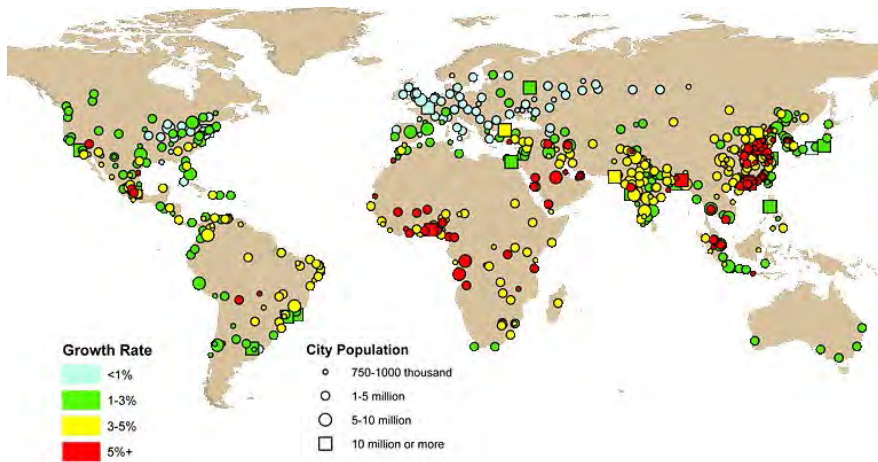


Figure 2. Annual growth rates of urban agglomerations, 1970–2011 (UNDESA 2012).

<sup>1</sup> Executive director of the UN Environment Programme in 2006, opening a world congress in Cape Town on local solutions to global environmental problems.

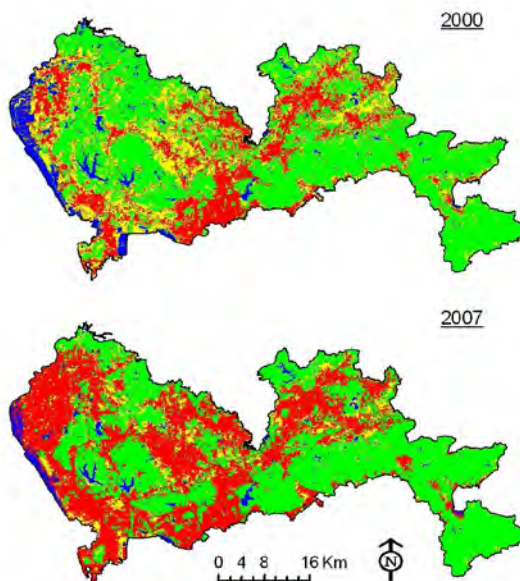


Figure 3. Shenzhen in 1980, a mainly rural landscape with villages (left); the same area in 2005, showing the very rich modern city with over 10 million people (right).

the USA, coastal South America and Australia — was at rates of <math><1-3\%</math> per year (Figure 2).

Of course urbanisation is not only achieved through the expansion of existing cities, but also through the increasing number of cities. In China, until 1978 there were fewer than 200 cities, but over the next 10–15 years the number of cities grew steeply and has now reached about 660, and stabilised (Bai 2008).

Figure 3 helps in visualising what these sorts of numbers and trends mean on the ground. At left is a photo taken in Shenzhen, just across the China–Hong Kong border, in 1980, and it shows that the landscape was predominantly rural with scattered villages involved in agriculture as well as fishery. At right is the same region in 2005 — seven years ago — taken from exactly the same spot. Shenzhen today has a population of over 10 million and is also one of the richest cities in China. So when we talk about urbanisation in China and in developing countries, this is the kind of scale, magnitude and speed we are talking about.



Growth at this scale is still continuing. Figure 4 shows Landsat satellite imagery of the land-use around Shenzhen in 2000 and 2007. The red colour indicates urban land-use. Even within this short seven-year period there was a large increase in the urban area.

Figure 4. Landsat imagery of land-use around Shenzhen in 2000 and 2007, showing the expansion of urbanised land (red colour) (Bai et al. 2012).

Shenzhen is an extreme example, but it is not exceptional. Urban land use in China grew strongly during 2004–08 at the provincial level, which includes cities and designated towns. In some relatively remote provinces, urban land use expanded at less than 8%. However, in the vast majority of provinces, urban land use grew at 8–26%, and in some provinces in south-east China the growth rates were larger than 26% (He et al. 2012).

Such rapid growth of urban land is of particular concern for China and probably for world food security as well, because China is feeding itself with less than 40% of world average per capita arable land. Therefore, rapid uptake of arable land for urban land use can really affect the food security in China and probably in the world in the long run.

### **Implications for agriculture**

Looking at urban land expansion more broadly, the total land taken up by major urban centres and cities is currently about 1% of the Earth's surface (UNDESA 2012). Some forecasts suggest that the amount of land in cities could triple by 2030, but that still does not seem a really large amount of land. However, urbanisation has significant implications for agriculture because it takes over arable land that could otherwise supply food. In fact, because most cities are located in the most fertile land on our planet, urbanisation of that very fertile arable land has a disproportionately high impact.

Other implications for agriculture come from the strong fundamental driving factors behind this kind of urban land expansion, which are very difficult to address. There are also indirect impacts on productivity and rural communities because of urban land expansion. Further, urbanisation is much more than just a demographic change; it changes the quantities and structural mix of the demand for food, and it changes lifestyles, all of which have significant impacts on agriculture. Finally, as mentioned above, there will be very strong pressure on food production concentrated in vulnerable or heavily populated regions in the world, such as China, India and Africa.

In China up to 80% of all agricultural land lost over the last decade was converted to urban areas. Between 1997 and 2006 more than 12,000 km<sup>2</sup> of land was converted into urban built-up areas (Bai et al. 2012). This has a strong effect on arable land because most urban centres are surrounded by arable land. For instance, in the Beijing-Tianjin-Tangshan area all non-urban land within a 10 km radius of each urban centre is arable (Tan et al. 2005).

### **Urbanisation correlated with economic growth**

To try to do something about this trend of arable land loss, it is important to understand the fundamental factors behind such expansion. Working with colleagues I have recently examined long-term data on 191 major cities in China, to look for the factors influencing such rapid urban growth (Bai et al. 2012). We find that larger cities and richer cities appear to be growing more and getting richer faster. We also conducted a Granger causality test to see what is driving this trend. Our results show that larger cities tend to gain more income, and

richer cities tend to expand more. There is a strong long-term bidirectional causality between urban built-up area expansion and gross domestic product per capita, at both city level and at provincial level, and there is short-term bidirectional causality at provincial level. This means there is a positive feedback between landscape urbanisation and urban and regional economic growth in China.

This means that urbanisation, if measured by landscape indicators, has a causal effect on economic growth in China, both within the city and, through a spillover effect, in the region. Urban land expansion is not only the consequence of economic growth in cities, it also drives such growth. Under the current economic growth model in China, it may be very difficult for China to control urban land expansion without sacrificing economic growth. That is a really tough situation in which to make decisions. It means that China's policy of stopping the loss of agricultural land, for the sake of food security, might be strongly challenged by its policy of trying to promote economic development through urbanisation (Bai et al. 2012).

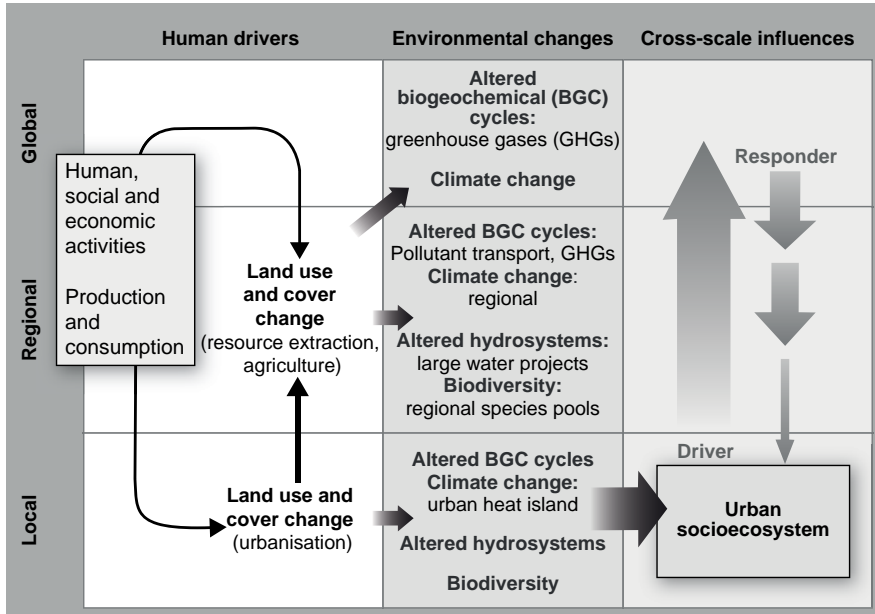
### **Indirect implications for rural areas**

There are also indirect impacts on productivity and rural communities. With colleagues in China, I have examined how land use expansion affects rural communities in China. We find that land use changes associated with urbanisation have increased the social vulnerability of traditional farming communities in the peri-urban areas (Huang et al. 2012). The vulnerability can last for up to 20 years before it levels off or increases further. In those 20 years, a new generation grows up and people can be integrated into the urban fabric and start new kinds of livelihoods. There are large impacts from urbanisation.

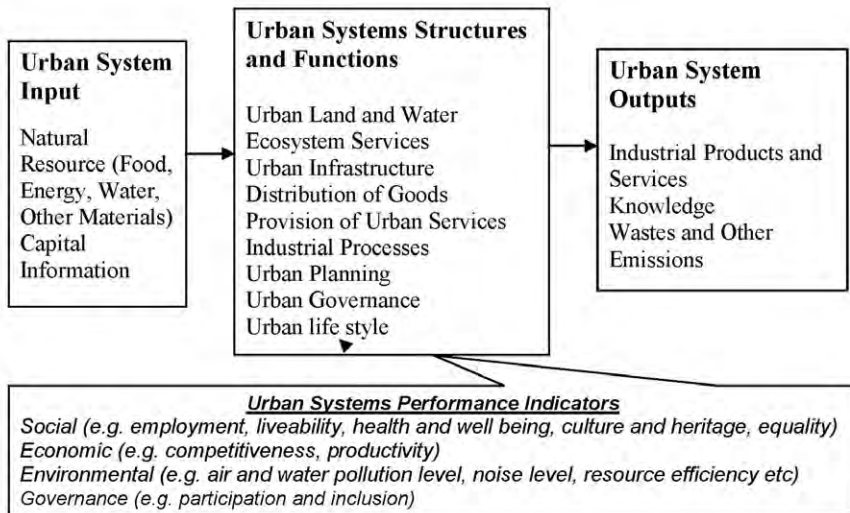
In other areas of China, the locals have seized the opportunity offered by urban areas. In those areas there is a very big increase in social and economic capital in peri-urban areas (CCICED 2012).

The impact of cities extends beyond their physical footprints. Figure 5 is a conceptual diagram which shows that activities happening within cities are driving environmental changes at local, regional and global levels, and that these changes have a feedback effect on cities and force them to respond to the changes. Cities are responsible for most of the carbon emissions (78%) and most of the residential water use (60%), and 76% of wood used for industrial purposes.

Another way to understand the global impact of cities is to consider a city's 'urban metabolism': think of a city as a type of organism or system (Figure 6). Cities require considerable inputs from surrounding areas, including food, water and energy, and these are distributed within the cities and contribute to the functions and processes within cities. Then eventually there are by-products and outputs from the urban systems. Figure 7 is a conceptual model of the urban dietary flow of phosphorus (P), moving into the city in food, through the city via various pathways including people, and out into the environment (Li et al. 2012).



Figures 5 (above) and 6 (below). Interactions and feedback loops that link cities and their environments, including surrounding rural areas: inputs and waste products (outputs), and factors and responses (Grimm et al. 2008; Bai & Schandl 2011).



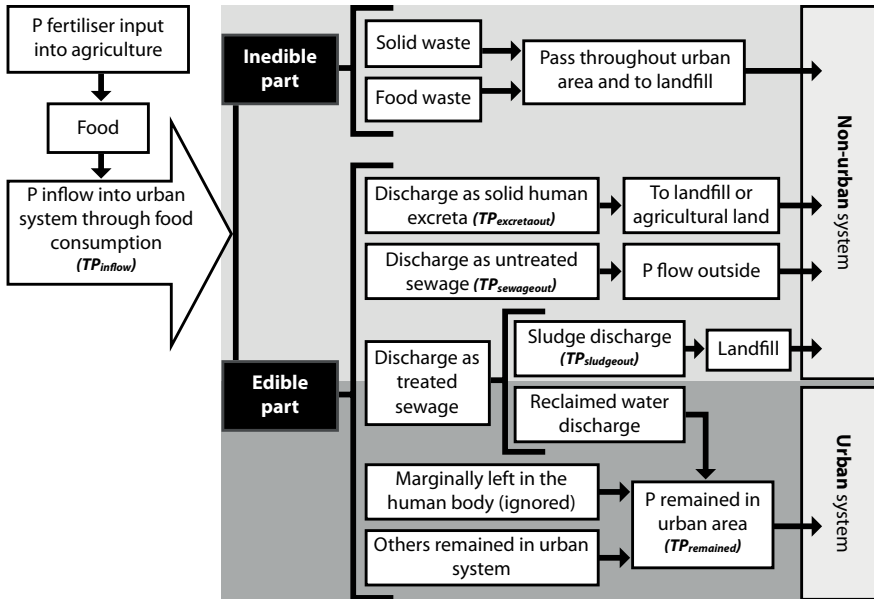


Figure 7. Conceptual model of the flow of dietary P (phosphorus) into and out of an urban system (based on Li et al. 2012).

On the input side, what happens within cities can significantly change the demand for food and the amounts that are imported into cities. I saw this question and answer on a Chinese website:

*What's growing faster than the Chinese economy? The Chinese people's waistlines!*

In fact, the answer refers to urban people's waistlines, not those of the whole Chinese people, indicating increasing food consumption by urban populations. There is an explosive growth of fast food stores in Chinese cities, including McDonald's. Urban people are consuming more meat, more fish, more dairy products, which in turn requires much more animal feed to support such a dietary change.

Now consider the output side. Our studies on urban phosphorus metabolism via food system shows an increasing amount of phosphorus metabolism through all cities, but their pathways can vary significantly. The graphs in Figure 8 support that point that what cities do, how rich they are and what they do about wastewater treatment and other wastes can strongly affect how much material they export into the surrounding areas, polluting the water and affecting the agriculture there (Li et al. 2012).

### Towards an integrated approach

In conclusion, this paper has shown that what happens in agriculture may largely be driven and determined by what happens in cities. Most of the literature looking into food security blames cities as culprits affecting food security. Yet

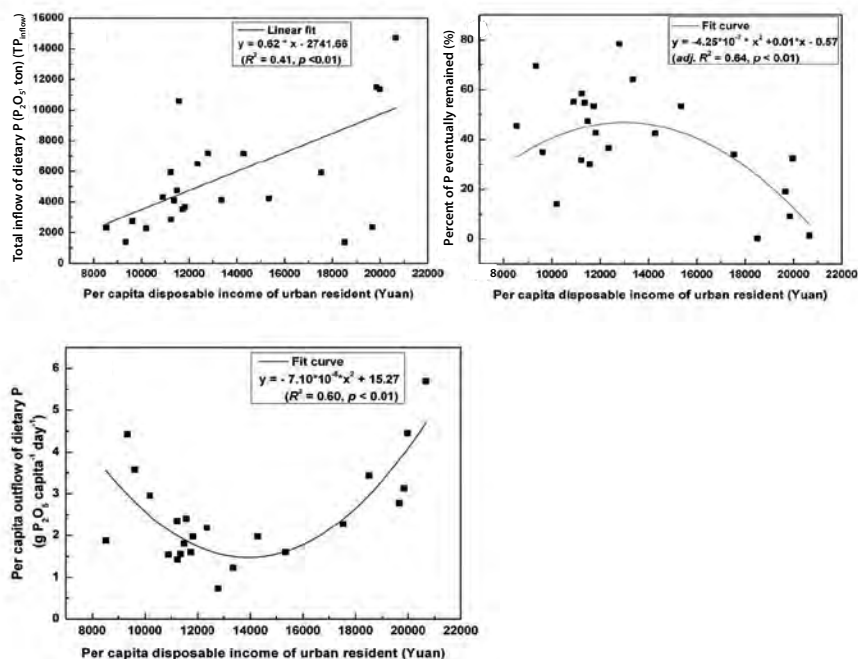


Figure 8. Relationship between per capita disposable income of urban residents and indicators related to dietary P flow in provincial capital cities of China (data for year 2006; Li et al. 2012).

simply blaming cities in that way does not help solve the problems. Urban issues are largely ignored in research into sustainable food production, as well as in policy-making — and equally, within the urban development research sector people pay very little attention to agriculture.

Urbanisation brings opportunities as well as challenges, and the question is: how can we harness and maximise the positive effects brought by urbanisation, and also avoid and compensate for the negative impacts?

We need a good understanding of the inter-linkages between urban and rural, or urban and agricultural systems. There is a very strong need for an integrated approach, rather than the dichotomised approach that is the norm today, in research and policy for urban development and for the food production debate.

## References

- Bai X.M. (2008). Urban transition in China: Trends, consequences and policy implications. In: Martin G., McGranahan G., Montgomery M. & Fernández-Castilla R. (Eds) *The New Global Frontier: Urbanization, Poverty and Environment in the 21st Century*. EarthScan, London, pp. 339–356.
- Bai X.M. & Schandl H. (2011). Urban ecology and industrial ecology. In: Douglas I., Goode D., Houck M. & Wang R. (Eds) *The Routledge Handbook of Urban Ecology*. Routledge, pp. 26–37.



- Bai X.M., Chen J. & Shi P.J. (2012). Landscape urbanization and economic growth: Positive feedbacks and sustainability dilemmas. *Environmental Science & Technology* 46(1): 132–139.
- CCICED (2012). *Taskforce Report: Strategy and Policies on Environment and Development in Western China*. China Council for International Cooperation on Environment and Development. Presented to Vice Premier of China Li Keqiang and other top leaders, December 2012. 69 pages.
- Grimm N.B., Faeth S.H., Golubiewski N.E., Redman C.L., Wu J.G., Bai X.M. & Briggs J.M. (2008). Global change and the ecology of cities. *Science* 319: 756–760.
- He C., Huang Z. & Wang W. (2012). Land use changes and economic growth in China. *Land Lines*, 2012. October.
- Huang Y., Li F., Bai X.M. & Cui S. (2012). Comparing vulnerability of coastal communities to land use change: Analytical framework and a case study in China. *Environmental Science & Policy* 23: 133–143.
- Li G.L., Bai X.M., Yu S., Zhang H. & Zhu Y.G. (2011). Urban phosphorus metabolism through food consumption: The case of China. *Journal of Industrial Ecology* 16(4): 588–599. DOI: 10.1111/j.1530-9290.2011.00402.x.
- Tan M. et al. (2005). Urban land expansion and arable land loss in China — a case study of Beijing–Tianjin–Hebei region. *Land Use Policy* 22(3): 187–196.
- UNDESA (2012). *World Urbanization Prospects, the 2011 Revision*. New York: United Nations Department of Economic and Social Affairs, Population Division.

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