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**Rural–urban change, boundary problems and environmental
burdens**

by

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Abstract

This paper provides a policy-oriented review of those environmental burdens in low- and middle-income countries that cross rural–urban boundaries but are not national or global in scale. Many of the most intense pollution and resource pressures originate in urban centres, and have their major impacts on the surrounding regions. Peri-urban zones are often far more environmentally unstable than either urban or rural settings. Rural–urban burdens can be especially difficult to accommodate within existing administrative systems/boundaries, particularly in countries where public authorities face severe financial difficulties.

Section 1 seeks to put these rural–urban burdens in context, both conceptually and empirically. Ever since the first urban centres developed, they have placed environmental pressures on the surrounding regions, and the ability of rural systems to respond to these pressures has been critical to the success of urban systems. When urban areas grow or become more affluent, however, their environmental relations with the surrounding rural areas tend to change. This section describes some of these tendencies and also describes some of the potential advantages that urban development provides for rural environments, before ending with a simple classification of factors that can make rural–urban burdens particularly serious.

Section 2 focuses on the different physical categories of environmental problems that cross rural–urban boundaries: those involving water, air and land, and those arising from peri-urban activity. These different categories provide contrasting examples of how urban development can affect rural environments, and vice versa.

Section 3 summarizes the policy and governance challenges posed by rural–urban burdens. The extent to which these are addressed depends on the quality of local governance and the extent to which these are supported by national environmental legislation and national or provincial/state governance systems that encourage and support inter-local government cooperation for freshwater and waste water management, air and water pollution reduction, and solid waste management.

1. Urbanization, economic development and environmental burdens in urban and rural areas – a conceptual framework

1.1. How rural–urban environmental relations shift with affluence

It is widely recognized that urbanization and economic growth tend to go hand-in-hand. Related spatial shifts in environmental burdens are often neglected, however. This section provides a simplified account of how urban development, as it has been pursued in recent centuries, affects both urban and rural environments. While economic and rural–urban distinctions only provide a crude framework for comparing human settlements over time and across space, a simple framework centring on these distinctions provides some often neglected insights into several of the world’s major environmental trends.

The tendency for affluent cities to disperse their environmental burdens

As cities get wealthier, their environmental burdens have tended to become more delayed and dispersed (McGranahan et al. 2001). The environmental burdens characteristic of very low-income cities involve hazardous living and working environments, which have an immediate impact on the lives and livelihoods of urban residents, particularly those living in the most deprived neighbourhoods. The environmental burdens characteristic of very affluent settlements involve global environmental pressures such as greenhouse gas emissions and resource depletion, brought about by their high consumption patterns, with impacts that are often very long term. All human settlements have environmental impacts on the rural areas that surround them, but the most severe rural–urban impacts are often found around middle-income cities, and especially the large, industrial cities that release large quantities of pollution into the surrounding environment.

How rural institutions determine the effects of urban resource pressures

Many of the environmental pressures that urban activities impose on the surrounding area involve either urban demands for rural resources or the use of rural land, water or air to dispose of waste/pollution. The consequences of these pressures depend on the physical and institutional circumstances in these rural areas. Some rural lands and waters are more susceptible to particular forms of pollution (e.g. the chemical make-up of soils affects sensitivity to acid precipitation), and some rural resources are more prone to overuse. Similarly, some rural institutions are more likely to allow particular resource pressures to result in overuse. Urban charcoal demands, for example, are more likely to lead to deforestation if the producers are seeking out uncontrolled forests and have no intention of returning, than if the producers are local residents harvesting wood from private or communal lands, having negotiated an agreement with the owners (see Box 1). In the extreme, demand for charcoal can motivate people to plant trees, thus extending forest cover.

Box 1. Urban charcoal demands and rural environmental degradation in Tanzania

Charcoal production has long been criticised for creating ‘rings’ of deforestation around those African cities where it is one of the principal household fuels. The logic is simple: charcoal requires large quantities of wood to produce, and if demand exceeds the sustainable supply, trees will be chopped down to produce charcoal faster than the trees grow back.

This presumes, however, that the charcoal producers have free access to the forests, and simply cut the trees they want with no regard to how this affects the remaining resources. In practice, the environmental consequences of charcoal production depend on other agricultural and forestry practices, as well as where and how the wood is harvested, and on post-harvest management practices, all of which depend upon rural institutions.

A study that traced charcoal back to its sources in the region surrounding three urban centres in Tanzania, Dar es Salaam, Mbeya and Shinyanga, found that local conditions, practices and institutions made all the difference. Most of the sites involved selective harvesting, with about half having been harvested previously, and environmental damage varied considerably among the locations. Relations to adjoining villages also varied. But most striking, the level of charcoal demand bore no obvious relation to the resource problems.

By far the greatest concentration of charcoal demand was in Dar es Salaam, but wood from uncultivated land or forested land was still able to supply the growing charcoal demand in this large urban centre. In Mbeya, the planting of forest plantations had provided a windfall level of wood for urban consumers. But in Shinyanga, the woodland resources had been exhausted by a history of agricultural clearances mixed with heavy grazing pressure and longstanding erosion problems.

This is one of many examples of the importance of the rural context in determining the impacts of urban pressures. The same pressure that leads to serious rural degradation in one setting may not be an environmental burden at all in another. At one extreme there may be sites where urban charcoal demands lead to deforestation on ecologically sensitive land, a disruption of water balances and severe erosion. At the other extreme, urban charcoal demands may lead rural producers to plant trees on marginal lands with a view to meeting future demands, or to practice more selective cutting and better management practices.

SOURCE: Hosier, Richard H. 1993. Charcoal production and environmental degradation: Environmental history, selective harvesting, and post-harvest management. *Energy Policy* 21 (5):491–509, and one of the authors' own fieldwork.

Why the net environment impact of urban economic development is ambiguous

Increasing production and consumption is environmentally ambiguous. It tends to increase both resource demands and waste generation. Superficially, the combination of economic growth and urbanization might seem to lead inevitably to greater and more concentrated environmental impacts. In practice, however, both economic success and urbanization can also bring greater technical efficiency (which reduces the waste per unit of output) and a greater capacity to avoid the negative consequences of environmental pressures. The net effect of increasing economic activity depends heavily on the institutional context, but often adds to the pressures on resources that are beyond the reach of functional environmental management regimes.

How urban centres displace rather than resolve their environmental burdens

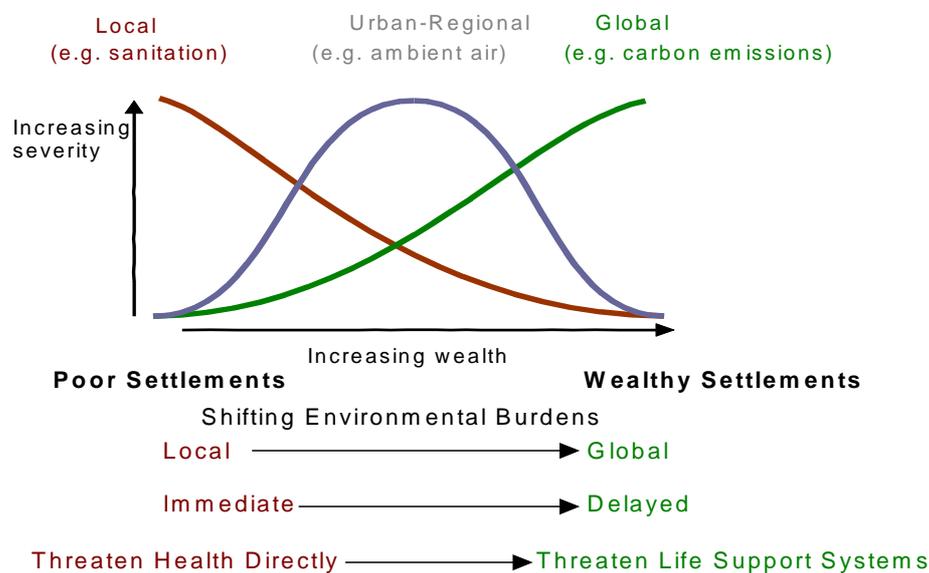
In some cases, measures to address the environmental problems within urban areas displace the burdens onto surrounding rural areas: human waste is flushed away into sewers and released in waterways; solid waste is collected and dumped beyond the urban boundaries; electricity substitutes for smoky fuels (shifting the likely location of environmental stress from the site of final consumption to the site of intermediate transformation – for instance, through air pollution if it is a thermal power station, or the environmental consequences of dams and reservoirs if produced by hydro-electricity). In many affluent regions, however, these rural–urban impacts have also

been reduced through a combination of extended environmental regulation, investment in waste treatment and pollution control, and a shift from industrial to service production. The pressures associated with consumption and environmental burdens that are global in scale still tend to increase with income.¹

The resulting environmental transition

The net result is that local environmental health problems tend to decline with average income, the pressure on the surrounding rural areas resulting from productive activities tends to increase with income and then decline, and global environmental pressures that result from consumption tend to increase. This is summarized diagrammatically in Figure 1.

Figure 1: A stylized environmental transition



SOURCE: McGranahan, G., P. Jacobi, J. Songsore, C. Surjadi and M. Kjellén. 2001. *The Citizens at Risk: From Urban Sanitation to Sustainable Cities*, Earthscan, London.

Examples of more complex rural–urban environmental interactions

Not all of the environmental challenges associated with urbanization are easily categorized in terms of environmental burdens such as pollution, waste or demand-driven resource depletion. One of the major concerns ecologists have raised about cities, for example, is that while ecological flows tend to contribute to ecocycles, urban systems tend to generate linear flows. This linearity can cause problems at the points of origin (e.g. the loss of soil nutrients), at the points of destination (e.g. the

¹ In the long run, the contribution that urban activities make to rural environments via global climate change may become the dominant rural–urban environment impact. The rural–urban relations of particular concern to this paper, however, are those that relate urban settlements to adjoining rural areas, and are regional in scale.

accumulation of heavy metals) or both (as in the case of nutrients that end up as sewage). Moreover, many of the most historically significant rural consequences of urban development have involved changes in the qualities (rather than just quantities) demanded by urban markets. The urban markets for meat and grain, for example, have contributed to the rise of rural monocultures, for example. To complicate matters further, because of the way markets operate, falling demand can be just as damaging for some resources as increasing demand can be for others.

Economic globalization and changing rural–urban linkages

Few cities play such a critical role in the environmental development of their hinterlands as 19th century Chicago did (see Box 2). Rarely do urban centres have quite such a great influence on regional markets or have comparable opportunities for market-oriented innovation. Economic globalization has reduced the scope for individual urban centres to monopolize local trade, even as it has increased the economic reach of many urban centres. Nevertheless, the environmental importance of rural–urban linkages clearly extends beyond the environmental impacts such as pollution, waste generation and resource consumption that are associated with urban activities. And through rural–urban linkages, extra-regional or international demand may also be the dominant influence on changing land use, including changing forms of farming and forestry as well as shifts from primary production.

Box 2. Chicago’s role in the environmental transformation of the ‘Great West’

There has been very little documentation of the complex and changing environmental relations between urban and rural areas. One of the exceptions is Cronon’s history of 19th century Chicago and the Great West (Cronon 1992). Chicago’s grain trading was intimately linked to changes in the biodiversity and species composition of the surrounding prairies: the use of grain elevators spurred the trading of receipts for grain deposits of a known quality, which at once created a demand for the standardization of the grains produced and spurred new marketing innovations such as futures markets for grain. Somewhat analogously, but through a very different process, Chicago’s lumbering operations helped to change not only the extent of forests but also the mix of trees. And Chicago’s stockyards helped to ensure that cattle and pigs populated the countryside. Meanwhile, many products of nature that had little value on the emerging urban markets (e.g. bison) were priced so low that they were consumed to near depletion.

This example serves to illustrate how the quality of urban demands can be as important as the quantities demanded, and also re-emphasizes the importance of rural institutions. In this case, however, the institutional changes in the ‘Great West’ were themselves heavily influenced by urban developments.

SOURCE: Cronon, William. 1992. *Nature’s Metropolis: Chicago and the Great West*. New York: W.W. Norton.

1.2. The environmental advantages urbanization can bring at different scales

Partly because of the demands urban systems place on ecosystems, resources and sinks in the surrounding region, cities and towns are often presented as environmentally damaging. This is misleading. Environmentally damaging production and consumption are often concentrated in urban areas. Achieving similar levels of economic production and consumption with people and enterprises in more dispersed

locations can be even more environmentally damaging. Moreover, addressing urban environmental problems is possible, while direct attempts to prevent urbanization can be very costly in social, economic and even environmental terms.

In some situations, promoting urbanization may even be part of a strategy to protect the environment from degrading rural development, although again, much depends on the extent to which urban environmental burdens can be mitigated. In dryland areas, for example, intensive agricultural development can be very damaging to the environment. Well-managed urban systems can be far less burdensome. Moreover, if they are extremely well managed, urban water regimes can create pockets of 'green' in dry zones, through measures which, for example, turn the relative impermeability of urban surfaces into a means of concentrating water in strategic peri-urban locations. The choice between urban and rural development is rarely posed in such stark terms, however, and the more obvious means of reducing environmental burdens is to concentrate on realizing the environmental advantages of urbanization where it is occurring.

A number of the environmental burdens of urbanization are detailed in other sections of this paper. Some of the potential environmental advantages include:

For **urban and peri-urban** environmental living conditions:

- lower costs per capita of providing piped treated water, sewer systems, waste collection, clean fuels and many other environmental services;
- more possibilities for local governments to fund or manage other forms of infrastructure and services that reduce environmental health risks (e.g. enforce pollution control and occupational health and safety).

For **regional** environmental burdens:

- high population densities, reducing the per capita demand for occupied land;
- a concentration of major polluters, facilitating pollution control.

For **global** environmental burdens:

- compact urban settlement patterns, reducing transport distances, increasing opportunities for more energy efficient public transport, and thereby reducing carbon emissions;
- economies of scale and agglomeration, making electrical co-generation possible and facilitating the use of waste process heat from industry or power plants for local (neighbourhood) water and space heating, again reducing carbon emissions.

1.3. Explaining rural–urban environmental burdens

As noted above, while rural–urban environmental burdens tend to vary with economic status, their severity is far from pre-determined. Local factors are extremely important, and often dominate. This is one of the reasons why both explanations for local rural–urban environmental problems and the appropriate policy responses need to be locally grounded. One of the few generalizations that can be made is that whatever a city's economic status, better governance is likely to result in better environmental management.

It is also possible to identify some of the characteristics typical of environmental problems. Several of these characteristics involve the way environmental impacts

cross the boundaries of property, politics and even intellectual disciplines. A lack of understanding of environmental processes is often part of the problem, although as noted below this is often as much a symptom as a cause.

Ignorance

People are often ignorant of environmental burdens, and have little incentive to become better informed. From 19th century ignorance about the relationship between water contamination and cholera, to 20th century ignorance about the relationship between carbon emissions and global climate, a lack of understanding has often played a part in environmental inaction. It is often held that urban dwellers are less aware of their dependence on natural processes, and that urban consumers and producers are less likely to see the environmental impacts of their actions. At least as important, people are not inclined to try to learn of the negative consequences of their actions if they know that they are going to continue acting in the same way regardless. In many circumstances, ignorance is as much a symptom as a cause of environmental negligence, and people would make more effort to uncover the environmental consequences of their actions if economic externalities (see below) did not ensure that they did not have to bear the costs. More specifically, ignorance and institutional problems reinforce each other. Most industrial polluters would probably just as soon not know that the pollution is destroying the livelihoods of downstream fishermen, if they are going to continue polluting regardless. Government officials would also probably just as soon not know, if they not going to take preventive action. Those affected have no incentive to find out more, unless they can expect to change things. Better information is rarely, in itself, enough to ensure that rural–urban environmental burdens will be addressed. However, if used strategically, responding to both the physical and institutional contexts, better information can certainly play an important role.

Economic externalities

Many urban environmental burdens (at every scale) involve what economists term ‘externalities’: the consequences of one party’s action or decision on another party’s well-being are incurred without any negotiation or agreement on compensation. The right to pollute is rarely bought and sold, so in the absence of governmental or social restraint pollution tends to be excessive. Resources that are not privately owned or managed by governmental or civil society organizations tend to be overused. Ecosystems do not respect the boundaries of private property, and property owners can affect the ability of ecosystems to function effectively, with consequences for others. It is widely recognized that urban externalities exist, and that simply allowing urban environments to change spontaneously in response to market pressures would be extremely damaging. Nevertheless, it can be difficult to address economic externalities, particularly when there is a lack of information or when the economic externalities are compounded by political problems.

Political externalities

Government responses to environmental problems also tend to be inhibited by the way they cross spatial and sectoral boundaries. Urban authorities are inclined to ignore the rural impacts of urban activities, and vice versa. Often, the areas where urban development is most rapid, on the periphery of existing urban settlements, are officially beyond the boundaries of the urban authorities – or, if within large cities, in relatively new and weak municipal authorities. Most environmental problems also cut

across the responsibilities of different government ministries and agencies, and while environment ministries often have a multi-sectoral brief, they typically find it easier to enforce legally prescribed standards than to negotiate equitable and efficient solutions. In short, there is a political equivalent of the economic externalities that can prevent markets from addressing rural–urban environmental burdens, arising from the fact that these burdens are crossing administrative boundaries.

Political inequities

In many cases, the groups most affected are politically vulnerable, compounding the difficulties arising as the result of economic and political externalities. Many environmental burdens fall most heavily on either low-income groups or on future generations, transforming their vulnerability into inequity. Future generations are politically vulnerable in that they cannot participate in the political arena. Low-income groups are potentially vulnerable in that they are typically deprived of political influence and often are excluded from political processes. This is often compounded by little or no protection from the rule of law. Low-income rural dwellers may have even fewer possibilities for legal protection and political voice than low-income urban dwellers although, in many urban contexts, large sections of the urban population are excluded from citizen rights and entitlements (including the right to vote and to access public services) because they live in illegal settlements.

Ignorance, economic externalities, political externalities, political inequities and many other institutional problems can lead to environmental burdens at different scales. The appropriate responses vary, however. Governance institutions appropriate to negotiating reduced pressure on global ecosystems are different from those appropriate to negotiating improvements in local water and sanitation facilities, and different again from those appropriate to negotiating improvements in rural–urban relations. Governance institutions at the sub-national, but extra-urban, scale are often particularly weak. It is perhaps indicative that the tools and methods that have been developed to give some indication of how cities transfer environmental burdens focus on the transfer of costs to the global system, not to their regions. For instance, the measurement of a city's ecological footprint is primarily to indicate its draw on resources and sinks worldwide, not on its immediate surrounds. The calculation of the material intensity of goods or services is also focused on global costs. There are methods that have been developed to get a better idea of the environmental impact of urban centres on their surrounds, including diagnostic processes associated with some local agenda 21s (see AtKisson 1996; Velasquez 1998) and environmental audit procedures (Haughton 1999). These methods have not, however, been widely applied.

2. Urban development, rural environments (and vice versa)

While rural–urban environmental burdens can often be ascribed to institutional failures (e.g. political externalities, political inequities, economic externalities), and can usually be addressed with institutional remedies (e.g. regulations, political organization, re-governed markets), the challenges they pose are also rooted in the character of the physical processes they involve – if not, they should not strictly be described as environmental problems. The following sub-sections examine rural–urban environmental issues involving water, air and land. While the characteristic problems vary, boundary problems arise in every case. The primary purpose of the

section is to review the different forms these problems take, rather than to identify particular responses. These descriptions also, however, illustrate how the character of the problem determines the range of effective responses.

2.1. Water

Historically, urban centres have often been founded near water sources and waterways, both to provide for urban water demands and to take advantage of water transport. Water is also a resource with a strong regional dimension. First, freshwater resources from within or around the urban centre are still the major source of urban water consumption, unlike many other resources that can more easily be imported from great distances (although ‘virtual water’ can be imported in the form of goods that require large quantities of water to produce). Second, intra-regional water flows constitute critical connections between urban systems and the surrounding regions, and unintentional changes to these water flows can create serious problems. And third, water pollution often has its principal impact on the surrounding region.

Water enters and leaves urban areas in almost equal quantities, but while it is flowing through urban areas it is likely to be used, polluted and otherwise transformed. A common result is that the water conditions downstream of urban centres deteriorate more than they do upstream. As illustrated in Box 3, this can influence the patterns of urban and peri-urban development.

Box 3. Rural–urban linkages downstream and upstream – examples from Hanoi

Rural–urban environmental impacts are so widespread that it has become axiomatic that being upstream (or upwind) is preferable to being downstream (or downwind) of major urban agglomerations. This can become self-reinforcing, as more desirable developments locate upstream and less desirable ones locate downstream. Hanoi, located along the Red River and its delta, illustrates these tendencies.

The rivers and streams of Thanh Tri district, south of the city, contain pollution accumulated as the water passed through Hanoi, and the smells alone can put off developers considering where to site high-class housing estates or commercial establishments. For people living and working in the area, the pollution is not only unpleasant but a serious threat to health. After heavy rains, the area is also susceptible to flooding as the result of urban run-off: as vegetated areas are turned into roads and buildings, and generally become non-porous, less of the water soaks into the ground, and peak discharges increase. Farmers have had difficulty protecting their rice fields, and have had to forego second harvests and turn more rice fields into seasonal or permanent fishponds.

At the other extreme, peri-urban areas north-west of Hanoi are known for their ‘flower villages’. In new urban wards, developers are investing in high-class housing estates, hotels and offices, often as joint ventures between government and foreign investors. Deforestation further upstream is reportedly contributing to flooding, even in these areas north of Hanoi, but the floods are comparatively well controlled and the water is clean.

This case illustrates how rural–urban linkages vary even around a single city, and demonstrates how environmental inequities, if they are not addressed, can easily be transformed into economic inequities.

SOURCE: van den Berg, L. M., M. S. van Wijk and P. Van Hoi. 2003. The transformation of agriculture and rural life downstream of Hanoi. *Environment and Urbanization* 15 (1):35–52.

In order to meet urban demands, water is often diverted considerable distances, and may involve inter-basin transfers. In assessing how urban development affects water systems in the surrounding region, it is important to consider:

- Urban → Upstream: how measures designed to meet urban demands for water and hydropower have been changing the ‘upstream’ water flows, affecting, for example, the availability of water for urban and non-urban users upstream.
- Upstream → Urban: how rural land use changes and water use and pollution affect downstream urban areas.
- Urban → Downstream: how urban water and land use changes have been affecting the qualities and quantities of water available ‘downstream’ (including coastal waters).

Conflicts between urban and rural water interests

During the 19th and 20th centuries, rapidly growing and economically successful large urban centres often relied on bringing in water from increasingly distant sources. While urban water demands rarely account for the majority of water withdrawals within a nation, conflicts between urban and non-urban users are common. Urban water use requires higher quality and more stable supplies than most rural use, and the social, economic and political importance of cities often ensures that their demands are given priority. The manner in which the water demands of Los Angeles were allowed to dominate over those of Owens Valley provides a well-documented example (Kahrl 1982).

Other water conflicts that cross rural–urban boundaries

In many instances, there are powerful interests in both urban and rural areas, and low-income populations are losing out regardless of their location on the rural–urban continuum (see, for instance, the discussion of water use and water shortages in Guadalajara in von Bertrab 2003). Water may be diverted to urban areas on the grounds that many urban dwellers do not have sufficient water to meet their basic needs – but there is a big difference between getting water to urban piped water networks and getting the piped water networks to the urban poor. Alternatively, getting more water to low-income groups in and around urban centres need not involve diverting more water from rural areas, let alone from low-income dwellers lacking adequate water resources.

The increasing spatial extent of urban water withdrawals

In most parts of the world, the spatial range of urban water withdrawals is expanding, however. In countries with capital-intensive water infrastructure, some of the regional water systems have become so closely integrated that it is no longer meaningful to link urban centres with spatially delimited supply networks – as with electricity systems, they are simply ‘attached to the network’ (Baumann, Boland and Hanemann 1998). Even where there is less water infrastructure, many cities are reaching further upstream for more and fresher water resources, sometimes even from other river basins. Research on the changing urban water systems in Africa, where inadequate infrastructure is often cited as a major problem, indicates that while in the early 1970s, many major cities still used groundwater supplies as their primary water sources, by the 1990s the primary water sources were more likely to be rivers, and increasingly these river sources were more than 25 kilometres away (Showers 2002). The construction of dams and canals, and the water diversions themselves, can have

major impacts on upstream ecosystems. In some cases, the effects on human well-being are clearly discernable – as when, for example, dams provide habitats for the freshwater snails that spread schistosomiasis. More often, the effects are complex and difficult to quantify – as when, for example, wetland habitats are lost.

The tendency to neglect ecological water requirements

When cities and surrounding rural areas are competing for water resources, ecological water requirements (the water needed to maintain ecosystem function and local hydrological cycles) are often neglected. The local ecosystem impacts can be significant. In the case of Tianjin, for example, over-pumping of the groundwater resulted in dropping groundwater tables and land degradation. Hundreds of small lakes and ponds disappeared because of the reservoir construction in the upper streams, resulting in a dryer local micro-climate. Unfortunately, even when the costs imposed by the lack of ecosystem functions are clearly high, they are dispersed and long term, while the interests that drive the political and economic agendas most effectively are tightly organized and immediate.

The tendency to neglect the benefits of investing in upstream watersheds

There is also a tendency to neglect the potential benefits to urban water supplies of more ecologically sensitive agricultural and other land use practices upstream. The use of agricultural fertilizers and pesticides pollutes urban water sources. Cultivated systems can also lead to erosion, siltation and more flooding in downstream urban areas, as well as damage to water storage facilities and water conveyance services. An economic analysis of alternative measures to improve water supplies in New York City found that, in many cases, it would be cheaper for the city's residents to pay upstream individuals and enterprises operating in the city's upper watershed to adopt less damaging practices than to invest in more water supply and treatment facilities. The same is true for São Paulo (van Horen 2001) and almost certainly true in a wide range of urban centres. There have been a few attempts to develop markets for watershed services and, for the most part, the legal and institutional basis for such markets are lacking. Instead, the emphasis has been on regulatory regimes that attempt to define standards or practices to protect water resources.

How urban water systems can harm downstream users

Urban centres themselves can cause a wide range of problems for downstream people and ecosystems, including those in other urban locations. Urban areas usually have a high percentage of paved areas; they concentrate rainwater rather than dissipate it. This can intensify flooding and cause flash floods. Changes in the water flows can also affect downstream fish stocks, recreational opportunities and biodiversity. Sewers convey human waste out of urban locations, often releasing it untreated into local waterways or coastal waters. Human waste not only poses a health risk for people who might come to ingest the contaminated water, but can also cause eutrophication and damage to aquatic ecosystems downstream. Chemical water pollution is also a major problem, particularly around large industrial centres.

Coastal zones and urban water systems

Coastal zones are among the worst affected by urban development, and combine many of the most critical land and water issues. As indicated above, the share of land in coastal zones that is urban is particularly high, and land conversion and habitat losses in coastal systems are often irreversible. Coastal development and construction

lead to conversion of coastal wetlands (marshes, seagrass beds and mangrove forests), dune systems and coral reefs. Urban areas at river mouths constitute a bottleneck for aquatic migratory species. Other particularly stressful situations related to urban areas in coastal systems are the development of ports from natural harbours, the dredging of shipping channels, and the development of industrial centres on the coastal fringe. Port development also creates a risk of species invasion, with large ships in harbours acting as vectors, with species introduced via ballast water transfer and hull fouling.

2.2. Air ²

Air pollution can cause problems at every scale, ranging from personal exposure to hazardous pollutants at the point of emission, to the regional impacts of acidification arising from emissions of oxides of sulphur and nitrogen, to the global climate change resulting from emissions of carbon (and other greenhouse gases) anywhere in the world. There is still a strong tendency to treat these air pollution issues separately, and to treat rural–urban linkages as relatively unimportant. There are, however, a number of cross-scale effects that deserve to be taken more seriously, several of which cross the rural–urban divide. If these cross-scale effects are ignored, there is a danger that measures to address problems at one scale will exacerbate problems at other scales, for example, when the higher stacks used to reduce local air pollution problems contribute to acid precipitation further away. There is the potential, however, to use cross-scale effects to exploit synergies and find the best means of reducing air pollution problems at all scales.

Household–Settlement

Concentrations of air pollution in homes where cooking or heating involves the combustion of solid fuels in poorly vented stoves are a major source of human exposure to health-threatening air pollution. The use of chimneys to reduce indoor air pollution contributes to ambient air pollution. Especially in peri-urban areas, where biofuels are readily available and yet densities are high, household fuel use contributes significantly to ambient air pollution in the neighbourhood. Research in Pune, India, for example, indicates higher outdoor air pollution levels in neighbourhoods of biomass-using households than in gas-using areas, with kerosene-using areas somewhere in between (Saxena and Smith 2003).

Settlement–Surrounding area

Local emissions can disperse and contribute to settlement-wide ambient air pollution and, in addition, certain types of pollution involve transformations in the environment that take place away from the site of emission. Ozone, for example, can form over a period of hours (in the right conditions), creating concentrations quite far from the site where the precursors were originally emitted. Some particulates are also formed through chemical reactions in the atmosphere. These particulates and ozone may be created outside of the urban centres where the emissions originated, imposing health risks in areas downwind, as well as damage to crops.

² This section draws on a chapter on different scales of air pollution, prepared for a recent book on air pollution in rapidly developing countries: Smith, Kirk and Sameer Akbar. 2003. Health-damaging Air Pollution: A matter of scale. In *Health and Air Pollution in Rapidly Developing Countries*, edited by G. McGranahan and F. Murray. London: Earthscan.

Settlement–Region

Acid depositions (e.g. acid rain) are the result of emissions of oxides of sulphur and nitrogen, which can be carried hundreds of kilometres by the air. Sulphur, the primary source of acidification, comes mostly from coal and oil burning in urban areas or in more remotely sited power plants. In addition to harming crops, acid deposits can disrupt natural ecosystems as well as corrode human-built structures.

Region–Globe

Small particulates, some less than one-millionth of a metre in diameter, can stay in the atmosphere for months and, while their impacts are not well understood, there is a concern that they may have a cooling effect on the earth. The more significant long-term concern is that emissions of carbon dioxide and other greenhouse gases will result in global warming. Climate change could have profound impacts on rural ecosystems and agricultural production.

As with water systems, there are also rural activities that can affect urban air quality. The forest fires in Indonesia, for example, have caused serious problems in urban areas, with impacts comparable to that of severe urban smogs, including elevated mortality rates and higher prevalence of respiratory diseases (Sastry 2002; Yadav et al. 2003). Also, coal-fired power plants located in rural areas can lead to acid corrosion in urban areas. For the most part, the direction of impact is urban to rural. However, as illustrated in the case of Ilo, summarized in Box 4 (and examined in more detail in Boon, Alexaki and Becerra 2001), air pollution crosses rural–urban boundaries in a variety of ways, and this in itself is a serious challenge when it comes to assigning responsibilities and holding those responsible to account.

Box 4. Rural–urban air pollution around Ilo, Peru

A large copper smelter located north of the city of Ilo along the coast of Peru has contributed to poor air quality in the city of Ilo since 1960. For 35 years, sulphur dioxide was emitted with no controls. In the last decade, progress has been made in addressing these air pollution problems. Significant challenges remain, but a better basis for negotiating improvements has been created.

In Ilo, the health of the 70,000 residents is put at risk due to exposure to sulphur dioxide and other air pollutants. The residents have understood for some time that this air pollution poses an appreciable risk. Ilo began to innovate with participatory forms of urban management in the 1980s, and gained international recognition for its innovative environmental management in the 1990s – there is a comparably high level of environmental awareness and action. There has also been an expanding air pollution monitoring system, initiated in 1997.

The residents of Ilo are not the only people affected by the pollution. There are other urban centres situated 60 kilometres north of the smelter, and the predominant wind direction is north-north-east. There has also been crop damage in the Ilo valley, and farmers have received compensation from the smelter company for this damage. Farmers elsewhere have also claimed damages, although as of 2001 they had not received compensation, partly because there is no monitoring programme in the area. Acid deposits have also been affecting the natural vegetation. The natural desert vegetation, called *lomas*, has almost disappeared from the region because of the pollution.

In Ilo, serious attempts have been made to address this complex of rural–urban environmental linkages. Ilo's positive vision of the future, its local authority committed to consultation, and its consistent leadership have proved to be very effective in addressing

environmental issues in the past. It is in such settings that better information about environmental impacts are most likely to result in positive changes.

SOURCES: Boon, Ronald G.J., Anastasia Alexaki and Ernesto Herrera Becerra. 2001. The Ilo Clean Air Project: a local response to industrial pollution control in Peru. *Environment and Urbanization* 13 (2):215–232; Follegatti, José Luis López and Micky Hordijk. 1996. Innovative urban environmental management in Ilo, Peru. *Environment and Urbanization* 8 (1):21–34.

2.3. Land³

Urban areas' physical expansion is almost always over rural areas, and so the most obvious environmental change is that associated with the expansion of the built-up area and the immediate environmental impact of the urban activities that develop there. But expanding urban areas transforms not only the land that becomes urbanized (which covers only 1–2 percent of the total area in most nations) but also much larger areas, as can be seen in the changes in the rural landscape and ecology driven by productive activities that respond to urban-based demand for inputs (e.g. water and raw materials), goods and services. Large demands are made on the regions around cities for building materials and landfill, as a result of the construction of buildings, roads, industries and other components of the urban fabric. Many of the urban-generated solid wastes impact the surrounding region – for instance, as solid wastes are transported there and often disposed of on open-air sites with little or no provision for protecting surrounding soil and water from contamination. This section concentrates on land use changes and their environmental implications in and immediately around built-up areas

The kinds of land use changes that typically occur around a growing city include:

- land parcelling and residential lot developments (legal and illegal);
- large volumes of soil being removed for landfill, brickworks and building embankments; also, generally large quarries;
- legal and illegal disposal of household refuse and industrial waste (which may include hazardous wastes); also, motor vehicle salvage and junkyards around larger or more prosperous urban centres;
- spontaneous settlements (including squatter settlements), many of which are on sites at risk from landslides or floods;
- residential and tourist facilities serving higher-income groups (often gated communities in wealthy cities, recreational sites);
- industries (which may locate on the city periphery to escape more stringent environmental regulations);
- water purification facilities and sewage treatment plants;
- (usually) more intensive production of food in response to rising city demands, including expanding areas for horticulture and livestock; large-scale livestock units often posing serious pollution problems, as may intensive horticulture; and

³ This section draws on Hardoy, Jorge E., Diana Mitlin and David Satterthwaite. 2001. *Environmental Problems in an Urbanizing World*. London: Earthscan, although also drawing on more recent case studies of environmental changes in and around cities.

- gardens, cemeteries and parkland – that is, semi-natural landscapes where the dominant or most frequently occurring species are not native but accompanying and subordinated species (Morello et al. 2000)

Urban expansion and peri-urban land use changes

As noted in previous sections on water and air, it is difficult to draw a clear distinction between environmental impacts that occur within urban centres and those in peri-urban areas. First, the urban boundary is uncertain. Official urban boundaries rarely match the exact extent of the built-up area; they may be too small (as urban development has spilled over boundaries set many years ago) or too large (as urban boundaries have been defined that encompass large areas of agriculture, forest and water). In addition, urban systems in wealthier areas have spread, supported by more extensive highway systems, better communications and industrial structures that encourage more decentralized production systems. An aerial view of most major cities is no longer one of a concentrated urban centre surrounded by countryside, but of a complex spatial pattern of urbanized and non-urbanized areas with urbanized areas often stretching along major transport corridors for long distances beyond city boundaries. In addition, it is common for residential communities and industrial and commercial concentrations to develop close to major cities, but separated from the built-up area. In broad terms, the peri-urban interface refers to the immediate surrounds of urban centres, although it is difficult to establish its boundaries since, by definition, the peri-urban interface is subject to continuous processes of transformation.

It is also difficult to make generalizations about the nature of the peri-urban interface, which depends on the combination of a number of factors, including:

- the historical, social and cultural characteristics of the region, which may affect the spatial organization of living arrangements of households and communities;
- the economic base of the urban centre, including the existence or lack of demand for additional labour, hence the presence of migrants;
- the infrastructural base, which may determine, for example, whether urban development concentrates along corridors served by transport links; and
- the geographical and ecological features, which are also likely to determine activities and development of built-up areas.

Moreover, peri-urban areas around any urban centre are not necessarily homogenous: high- and middle-income residential developments may dominate one section (usually upstream from the built-up centre), others may host industrial estates, and others may specialize in horticultural production, stimulated by urban demand. Other sections may provide cheap accommodation, often in informal settlements, to migrants and low-income urban residents who cannot afford to rent in more central areas or whose accommodation needs are better served in such settlements. In southeast Asia, extensive transport infrastructure and the concentration of public and private resources in large urban centres such as Bangkok have resulted in the emergence of extended metropolitan regions where agricultural and non-agricultural activities are spatially integrated. Comparable developments are likely to be taking place in and around many major cities in other regions, although documentation is lacking on its scale and nature. Thus, the land use changes discussed here are generally occurring both in urban areas and in peri-urban areas.

Where cities have boundaries that extend far beyond their built-up area, much of the 'peri-urban' population and many of the 'peri-urban' impacts will be within these boundaries. For instance, the population figures that are usually given for cities such as Shanghai, Beijing and Tianjin in China are for the populations in large local government areas that include significant proportions of people living in rural areas and working in forestry and agriculture. This confusion between local government area and city area explains why the city of Chongqing sometimes appears as the world's largest city, with a population of 30 million. This is the population in the municipality, which covers 82,400 square kilometres (about the size of the Netherlands and Denmark combined); the city population is around 6 million. Some cities have boundaries that greatly understate their real populations, because they have not been adjusted to include large, dense settlements that developed around them. Here, much of the 'urban' population and 'urban' economic activities may be classified or considered as rural. For instance, the population of Colombo in Sri Lanka is often given as around 642,000, but this was the population in 2000 in 'Colombo municipal council'; the urban agglomeration of which this municipal council is the centre has a much larger population.

Hazardous land sites for settlements

Tens of millions of urban households live on hazardous land sites in and around cities – for instance, clusters of illegal housing on steep hillsides prone to landslides, or in deep ravines, or on land prone to flooding or tidal inundation. Disasters are common, as large numbers of homes and neighbourhoods are destroyed or damaged by floods or landslides (in turn, often triggered by storms/high rainfall) and, often, many are killed or seriously injured. It is also common for large numbers of schools, health centres, roads, bridges and other structures to be destroyed or severely damaged, and for many households to lose their livelihoods. Smaller 'disasters', in which fewer people are killed, are much more common, and are often seen as routine events.

Most of those living on hazardous sites in and around urban areas are low-income groups. Rarely do they live there in ignorance of the dangers; such sites are chosen because homes can be constructed with less fear of eviction (as the hazards make the sites unattractive for commercial development) and because they are often the only locations available to low-income groups that are close to work opportunities. To the hazards inherent in the site are added those linked to a lack of investment in infrastructure and services. On steep hillsides, the introduction of water supplies with no provision for drainage can add significantly to the risk of slope failure. There may be a lack of knowledge among the settlers as to how to reduce risks – for instance, minimizing the amount of vegetation cleared from a slope as it is developed for housing, to reduce the risk of land/mudslides (Greenway 1987). Or the knowledge may be there but not the collective organizations to permit its effective use. For instance, those who have settled on a slope may be powerless to prevent new housing developments or a new road at the base of the slope, which puts the whole hillside at risk (Douglas 1986). It is also common for the risks to informal settlements to be increased by urban developments elsewhere – for instance, the intensity of flooding is increased for low-income settlements in a flood plain, as middle- or upper-income residential areas and commercial developments upstream are protected by flood embankments.

Uncontrolled or unregulated dumping of solid wastes

There are very large variations between urban centres in the proportion of residential, commercial and industrial solid wastes that is collected, ranging from those urban centres where most such wastes are collected to those where most are uncollected. But it is common for 30–50 percent of the population in major cities in low-income nations to receive no regular waste collection service, and for most waste disposal for industrial and commercial enterprises to be unregulated (Hardoy, Mitlin and Satterthwaite 2001). Smaller urban centres generally have lower levels of service provision (ibid). Organic waste is a valuable source of nutrients, but as illustrated in Box 5, it can be difficult for peri-urban farmers to access this waste.

Box 5. Solid waste flows in peri-urban Bamako and Ouagadougou

Solid waste can be a nuisance or a resource, depending on its location and composition. The organic component of urban solid waste can be a valuable resource for farmers in peri-urban sites, creating potentially beneficial rural–urban recycling. This potential is rarely achieved however.

Farmers in areas surrounding Ouagadougou (Burkina Faso) regularly arrange with municipal waste workers to have solid waste dumped near their fields. Much the same occurs around Bamako (Mali). Such uses contravene environmental and health legislation but are usually tolerated, in part because of the lack of more controlled landfill sites.

It can be difficult to document illicit practices, but a recent study indicates that there is considerable use of wastes in peri-urban agriculture, and that in some areas this practice has revived cultivation on degraded soils. Where farmers have insecure land tenure, the incentive to invest in improving soil quality is reduced. But the more serious impediment to improving upon this informal (and, in some cases, unhealthy) practice, is that government plans for improving waste disposal are inclined to ignore these potential rural–urban linkages, and to focus on large-scale formal solutions more likely to undermine than to build upon existing informal arrangements.

As these examples illustrate, these environmental issues can not only cross rural–urban boundaries and sectoral boundaries (agriculture and urban services), but also the boundaries between formal and informal activities.

SOURCE: Eaton, D. and T. Hilhorst. 2003. Opportunities for managing solid waste flows in the peri-urban interface of Bamako and Ouagadougou. *Environment and Urbanization* 15 (1):53–63.

Most of the solid wastes that are collected are disposed of on land sites with little or no provision to manage these sites (for instance, to prevent uncontrolled burning or the breeding of disease vectors) or to guard against wastes seeping or leaching into local water bodies. Dump sites are often in ecologically valuable wetlands, as these are often the most accessible undeveloped locations.

Many of these dump sites also receive toxic or otherwise hazardous wastes. In most urban centres in low- and middle-income nations, few measures have been taken to stop industries and other generators of toxic or otherwise hazardous wastes from disposing of these wastes without treatment (Clarke 1999; Hardoy, Mitlin and Satterthwaite 2001). A wide range of industries produce hazardous wastes, and most cities with such industries have contaminated land sites (and water bodies); also, most industrial centres have contaminated industrial sites (including those that have been

abandoned). Most cities lack the specialist facilities needed to safely process or store hazardous wastes. Many have no officially licensed treatment plants, so hazardous wastes have long been disposed of in conventional sanitary fills or on open dumps used for domestic wastes, or disposed of into water bodies or onto illegal land sites (usually without treatment to render them less hazardous), or kept in temporary stores within industrial sites. Even in countries where there has been progress in developing regulatory frameworks, there are often still serious problems with illegal dumps with hazardous wastes, and with industrial firms that still dispose of hazardous wastes illegally. For industries used to disposing of their hazardous wastes illegally, meeting good practice in disposal or storage can seem very costly. Decontaminating industrial sites and dealing with illegal dumps is also expensive. Addressing such problems is often particularly difficult when economies are stagnant, industries that have contributed most to the problem are unable to contribute to costs (or have the power to avoid doing so), and governments lack the funds to act.

Unregulated industrial activities by small and micro-enterprises

Economic activities in peri-urban areas around large as well as small and intermediate urban centres also concentrate large numbers of micro-enterprises, through which households move from farming to more diversified income-generating activities. In Vietnam, over 90 percent of households living in the urbanizing ‘craft and industry villages’ around smaller urban centres rely on non-farm income sources, often from activities such as rattan weaving or textile dyeing that have high polluting levels for both air and water (Thanh unpublished draft 2004). And in China, in the mid-1980s, it was estimated that town and village enterprises were responsible for one-third of gas emissions, one-sixth of water pollution and one-sixth of solid wastes in the whole country (Kirkby, Bradbury and Shen 2000). Environmental protection initiatives usually focus on concentrating such enterprises in locations where infrastructure and services can be provided with economies of scale. However, in many cases micro-enterprises that operate at the household level, usually through sub-contracting relations with larger enterprises, are not formally registered, and therefore easily escape identification; or do not have sufficient capital to relocate and pay for the services provided in industrial estates.

Uncontrolled peri-urban intensive agriculture

High-value horticultural and sometimes livestock (especially poultry) production are often a major economic activity in the peri-urban interface, where they benefit from easy access to urban markets. In many cases, commercial farmers take over from smallholder farms; this tends to result in increases in the use of fertilizers and pesticides, as well as waste from livestock, which can affect both the local areas and common resources, especially underground and surface water, in the city centre and in the surrounding rural region. This can bring major benefits and new income opportunities for significant sections of the peri-urban population, although as is almost always the case, the benefits are concentrated among the wealthier and better-connected groups.

Changing ecologies and diseases

The expansion of built-up areas, including the construction of roads, water reservoirs and drains, together with land clearance and deforestation often changes the local ecology in ways which favour the emergence or multiplication of particular disease vectors (World Health Organization 1992). Natural foci for disease vectors may

become entrapped within the suburban extension, and new ecological niches for the animal reservoirs may be created. Within urban conurbations, disease vectors may adapt to new habitats and introduce new infections to spread among the urban population. For instance, *Aedes aegypti*, the mosquito vector for dengue and urban yellow fever, proliferates in tropical urban settlements and, frequently, has been found breeding in polluted water sources such as soakaway pits, septic tanks and other breeding sites that have been found to contain high amounts of organic matter. Malaria has long been considered mainly a rural problem, but it is among the main causes of illness and premature death in many urban centres or urban peripheries; this is in part linked to informal settlements developing on sites with surface water where the *anopheles* mosquitoes can breed, and in part to inadequate or no provision for drainage, which increases the prevalence of such sites.

3. The policy challenges of addressing rural–urban environmental issues

Empirical relations between economic growth, urbanization and environmental burdens are sometimes taken to reflect policy choices. The curves in Figure 1, for example, could be taken to reflect the environmental benefits and costs of urban economic development. It is important to recognize, however, that even when such curves are empirically grounded, they reflect ‘average’ outcomes, and are not laws of development. At any given level of per capita income, environmental conditions vary between urban centres and over time, partly in response to policy and governance changes, and partly to whether the potential environmental advantages of urbanization have been realized.

Whether one considers the decline of local environmental health burdens, the rise and fall of regional burdens, or the increase in global burdens, the quality of local governance is central to shaping the curves. People do not connect to piped water and sanitation systems simply because they can afford to do so – improving access and preventing threats to public health have often been a defining responsibility of local government. Similarly, the waste and pollution produced by urban-based consumers and enterprises do not stop being dumped in the surrounding rural areas simply because cleaner alternatives can be afforded – good environmental relations between town and country, and the application of appropriate environmental regulations are outcomes of good governance, in this case linking urban and rural interests. The implementation of air and water pollution legislation within cities often reduces regional pollution burdens – as in Surat, in India, after its poor environmental reputation (and plague epidemic) threatened its prosperity (Robins and Kumar 1999), and in the Programme for Pollution Control, Evaluation and Rating applied in various Asian and Latin American nations (World Bank 1999).

Larger cities, where local governance is divided between different local authorities – for instance, metropolitan areas with many different local authorities – present a particular challenge for environmental management, including limiting transfers of environmental costs between local government areas. The more polluting industries and facilities (including solid waste dumps) tend to concentrate in the less wealthy local government areas. As noted earlier, population growth is often highest in certain local government areas on the periphery of the built-up area, including many with

weak and ineffective local governments. Meanwhile, the population and production systems in wealthier municipalities often transfer environmental costs to other areas, while also seeking to avoid contributing to the costs of good environmental governance for the whole region. Depending on the scale of the environmental burden, national and even international governance may be required but, in every case, securing the best means to reduce environmental burdens will require effective local governance. For all large cities, it will usually require cooperation between adjacent local governments – as in, for instance, Bamako and Ouagadougou, where collaboration between local councils, women and youth associations, local leaders and farmers promoted the collection and recycling of organic urban waste, which was sold to urban and peri-urban farmers (Eaton and Hilhorst 2003).

As described in previous sections, many of the challenges involve urban activities that cause damage to rural environments, but which do not take this damage into account. Environmental impacts often elude the market, and also fall between the responsibilities of different local or provincial/state governments and different sectoral ministries. From an environmental perspective, alternative boundaries such as watersheds or airsheds are advocated as more appropriate to managing environmental impacts. In practice, even water basin authorities face serious problems managing rural–urban environmental relations, especially in brokering agreements between the different interests within their boundaries (see, for instance, von Bertrab 2003).

This paper has concentrated on the environmental costs generated by urban-based production, consumption and waste generation, and how, where and to whom these are transferred. In listing these problems, it is easy to overlook the central role that urban production has had in all nations that have developed more prosperous and diversified economies. It is also easy to forget that most of the environmental costs noted in this paper are not inherent to urban development. Well-governed cities will reduce all the local environmental risks and most of the local–regional ones. There are examples of this being achieved in large cities (for instance, Porto Alegre in Brazil – see Menegat 2002) and smaller cities (for instance, Manizales in Colombia – see Velasquez 1998). In both these cities, some progress was also made towards reducing global burdens (for instance, investment in public transport to limit private automobile use, strong support for recycling). Most cities in Asia, Latin America and North Africa have made considerable progress in reducing environmental health risks for large sections of their population over the last 20–30 years, and many are developing the means to reduce urban–regional impacts. Most small, poor urban centres have levels of consumption and waste generation that are too low to make much contribution to global burdens. The means through which urbanization can occur, without transferring costs to surrounding regions and with transfers to global environmental problems kept down, are known. But they depend on good local governance and on appropriate national environmental frameworks to support them.

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