

municipal bonds — for different classes of cities and countries should be established according to the level of urban vulnerability and the speed of urban growth. The proportion allocated to risk management in small and mid-sized cities must grow. It is essential that investments go beyond improving technical infrastructures and physical assets (such as housing); also crucial is developing human resources and strong institutions¹⁰.

Improved monitoring of hazards, human susceptibilities and coping and adaptation processes by municipalities, cities and civil-society groups is also required. Monitoring by citizens would complement official government and international data and engage different groups. Finally, more emphasis should be given to understanding how national and local governance influence resilience at the community level in urban areas.

Strengthening the resilience of vulnerable small and medium-sized cities is where the success or failure of the UN's New Urban Agenda will be decided. ■

Joern Birkmann is director, and **Torsten Welle** is a senior lecturer, at the Institute of Spatial and Regional Planning, University of Stuttgart, Stuttgart, Germany. **William Solecki** is professor in the Department of Geography, Institute for Sustainable Cities, Hunter College, City University New York, New York, USA. **Shuaib Lwasa** is associate professor in the Department of Geography, Geoinformatics and Climatic Sciences, Makerere University, Kampala, Uganda. **Matthias Garschagen** is head of section at the United Nations University, Institute for Environment and Human Security, Bonn, Germany.
e-mail: joern.birkmann@ireus.uni-stuttgart.de

1. Vermeiren, K., Van Rompaey, A., Loopmans, M., Serwajja, E. & Mukwaya, P. *Landsc. Urban Plan.* **106**, 199–206 (2012).
2. Heinrichs, D., Krellenberg, K., Hansjürgens, B. & Martínez, F. (eds) *Risk Habitat Megacity* (Springer, 2012).
3. Hochrainer, S. & Mechler, R. *Cities* **28**, 53–61 (2011).
4. Garschagen, M. & Romero-Lankao, P. *Clim. Change* **133**, 37–52 (2015).
5. Satterthwaite, D. *Small and Intermediate Urban Centres in Sub-Saharan Africa* IIED Working Paper (2016).
6. Adelekan, I. et al. *Int. Dev. Plann. Rev.* <http://dx.doi.org/10.3828/idpr.2015.4> (2015).
7. *Humanity on the Move: Unlocking the Transformative Power of Cities* (WBGU, 2016); available at <http://go.nature.com/2cqq99n>
8. Welle, T. & Birkmann, J. *J. Extreme Events* **2**, 1550003 (2015).
9. Rosenzweig, C. et al. *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network* (Cambridge Univ. Press, in the press).
10. Birkmann, J., Garschagen, M. & Setiadi, N. *Urban Clim.* **7**, 115–133 (2014).



Where to put the next billion people

Richard T. T. Forman and Jianguo Wu call for global and regional approaches to urban planning.

By 2030, 1.1 billion more people will live on Earth — bringing the total to about 8.5 billion. Most of them will arrive in dense Asian and African cities, exacerbating pollution and resource shortages¹. Urban expansion alters a city's 'big seven': natural vegetation; agricultural land; clean water; jobs; housing; transport; and communities. Rapidly growing cities such as Kano, Niamey, Sikasso and Bobo-Dioulasso in sub-Saharan West Africa, for example, are already converting woodlands into irrigated farmland to feed their rising populations².

Urban planning can slow such degradation, and even improve matters. But protecting natural and agricultural land, water bodies and biodiversity are rarely top priorities for municipal governments. Planners focus

on creating jobs, housing, transport and economic growth.

A new approach to planning cities is called for: one that is both global and regional. It must consider which areas are best placed to support higher populations without greatly increasing the already heavy ecological footprint on our finite Earth.

Globally, planners should prioritize development in the most suitable (or 'least bad') areas. That rules out regions that are populous, resource-poor or hotspots for native biodiversity. It points to places that have the warm and moist climates amenable to growing crops, such as grassy and forested lands in temperate and tropical regions. We see promise in large areas in the Americas, central Africa and Asia as well as pockets of Oceania.



Urban-region plans need to maximally sustain farmland and nature, while creating viable communities instead of sprawl.

TYRONE TURNER/ANGC

Second, metropolitan regions need to manage where they absorb new arrivals. Currently people often concentrate in cities or areas of urban sprawl (see *Nature* 467, 900–901; 2010). Instead, compact settlements along the urban fringe and in surrounding satellite cities and towns should be encouraged. This provides space for sustainable communities and limits the loss of valuable land. Managed satellite-city growth can be seen around Barcelona, Spain, and compact communities have been established around Portland, Oregon, and Canberra, Australia.

Such a vision demands worldwide coordination. It will require international and national policies for environmental protection, urban development and human migration. And each city must develop an urban regional plan.

A working visit by one of us (R.T.T.F.) to Barcelona in 2002, including a memorable helicopter ride, showed how such planning can work³. Below, the city's chief planner had gathered mayors and leaders from across the region. Their conversation went something like this: "We're wasting land! We're all in this place together. No American sprawl wanted here. Save and improve our tight water supply. Rein in the floods. Stop shrinking our parks and conservation areas. Don't stick

band-aids on our transportation system. We need long-term economic strategies. Tourists and grapevines will not like our warming climate." Such conversations are needed to galvanize support for planning whole urban regions.

RISING PRESSURE

Like a tsunami, urbanization moves powerfully and swiftly across the land. City limits bulge; satellite cities grow; strip developments and sprawl spread. These last two are the most detrimental to the environment^{3,4}. The reason why expansion is so damaging harks back to the origins of cities. Most settlements began on good agricultural soil near a body of fresh water and natural vegetation⁴. Buildings, cultivation, pasture and woodland often evolved in concentric rings. Episodes of urban expansion therefore cover or pollute once-valuable natural resources at ever increasing range. Meanwhile, the exploding urban population is inundated with solid waste, wastewater, heat and pollutants.

This pattern applies to cities of all sizes, from small (fewer than 500,000 people) to mega (more than 10 million people). Around the edges of the small and mid-sized US cities of Salt Lake City in Utah, and Denver in Colorado, for instance, good agricultural soil has been covered with houses. Expanses of natural ecosystems have shrunk and

become fragmented and degraded. Semi-wild wooded recreation areas lie farther from the city's people. Wells have lowered the water table, dried out streams and wetlands and made wildlife scarcer. Similarly, Seoul has converted a greenbelt into a ring of parks that is separated by highways and new communities. Urban sprawl has taken place around cities across China at unprecedented scale and speed.

Climate change makes things worse by increasing the number and severity of heat waves, droughts, floods and days of bad air quality⁵. Expansion of coastal cities — such as Guangzhou, Mumbai, New Orleans, Osaka and Vancouver — puts more people at risk of flood damage from sea-level rise. The urban poor are among the most vulnerable.

Meanwhile, global food production will need to increase enormously. Feeding 1 billion new mouths only 14 years from now without drastic changes to the food system could require a few hundred million new agricultural hectares, an area about the size of Greenland, even India⁶.

SUITABLE PLACES

To see which areas of the world have physical conditions that could theoretically accommodate an extra billion people sustainably, we overlaid maps of seven variables from *The Atlas of Global Conservation*⁷. We ruled out regions with extreme or high water stress; other arid areas; tundra and ice; centres with species unique to a region; and regions with population densities that exceed 100 people per square kilometre, namely much of Europe, the Middle East, India and China and the western United States.

That leaves large areas of South America; parts of southern Canada and the northern

"Fit built structures around, rather than on, the valuable natural resources."

and eastern United States; south-central Africa; parts of Asia north of the Himalayas and from the Black Sea to north China; and scattered parts of

Oceania (see 'Habitable zones'). Some moist tropical areas could support crops such as cacao, coffee, oil palm, rice and maize (corn). But development should be prohibited in biodiversity hotspots such as Borneo, northern Queensland in Australia and parts of the Amazon basin.

The fact that these amenable places differ from regions where population growth is most rapid raises the issue of whether migration to more suitable areas will increase, especially as the impacts of climate change hit harder. Most people prefer to stay in their own nation. The costs of migration are high: breaking cultural and social ties, transport and rebuilding of communities and infrastructure. But staying put becomes less ▶

NATURE.COM
For more on cities, see:
nature.com/habitat3

► feasible as a population becomes more dense and environmental resources more limited. As the flight of refugees from today's Middle Eastern conflicts shows, the migration of tens or hundreds of thousands of people will challenge communities along the travel routes as well as in the source and recipient regions, which are mainly urban.

Of course, many more factors affect where people can or want to live, including job availability, quality of government, conflicts and secondary effects of population growth such as air pollution, wastewater, urban heat and loss of natural vegetated land.

And there are alternatives to settling more suitable regions. For instance, we could move everyone into compact cities; pump more water from deeper wells and aquifers; build thousands of desalination facilities; apply agricultural genetics to accelerate food production; or let climate warming turn boreal forest into farmland. But such ideas will be unsuccessful in the long term without widespread land, water and urban planning.

REGIONAL PLANS

Cities are so enmeshed in their surrounding regions that it no longer makes sense for them to be the sole focus of sustainable planning^{4,8}. Satellite images reveal patchworks of communities, industrial zones, farmland and natural ecosystems threaded by a web of transport links. For people and nature to thrive, the arrangement of land systems and water across the urban region (typically

70–100 kilometres in radius) must be managed holistically³. Urban region plans outline areas where water-supply protection, new compact communities, local food production, industrial centres and so forth are and are not appropriate, rather than pinpointing specific streets, developments and industries. They aim to sustain people and resources within the city and surrounding rings^{3,8}.

Some areas can accommodate more people better than others can. Inner cities and suburbs have too little land. Although city centres can be made more dense, for example by building upwards, they tend to have little green or outdoor space for families and suffer from excess heat, pollution and other environmental problems⁴. And unplanned growth beyond the city limits can destroy ecologically valuable land.

We suggest that growth be concentrated in four places: the outer suburbs; existing low-density sprawl areas just beyond the suburbs; satellite cities; and towns and villages within adjoining farmland. These peripheries are ripe for economic investment in jobs, parks, local public transport, water systems and housing^{3,8}. Compact communities facilitate neighbourhood ties, whereas scattered housing and roads characterize bad sprawl. Local officials and decision-makers will need policies and incentives to encourage sustainable development in these zones, particularly in

“Peripheries are ripe for economic investment.”

rural villages, which tend to empty out as residents move to cities for work.

Focusing on the region instead of the city will help to protect natural areas, water supplies, food-growing areas, air quality and natural resources. For example, New York protects land around its reservoirs to prevent water pollution; Sapporo in Japan guards its mountain slopes to provide cooling, erosion control, tourism, recreation and wood; so does Stuttgart in Germany, but for ventilation with clean air. Portland has set a limit for sprawl, and London enforces a greenbelt. Expanses of market gardens adjoin Valencia in Spain, and waste-water food-growing thrives next to Kolkata, India. Chicago has regional clean-air regulations; Edmonton, Canada, sites its industrial areas down-wind.

Yet urban region planning is scarce today. For good reasons — the areas are big and involve numerous jurisdictions, sectors and key societal functions. City planning is commonly done by experts in city centres or by architects focused on buildings. Typically the environment is addressed near the end of a planning process, and mainly to meet regulations.

The process needs to be reversed. Built structures should be fitted around, not on, valuable natural resources.

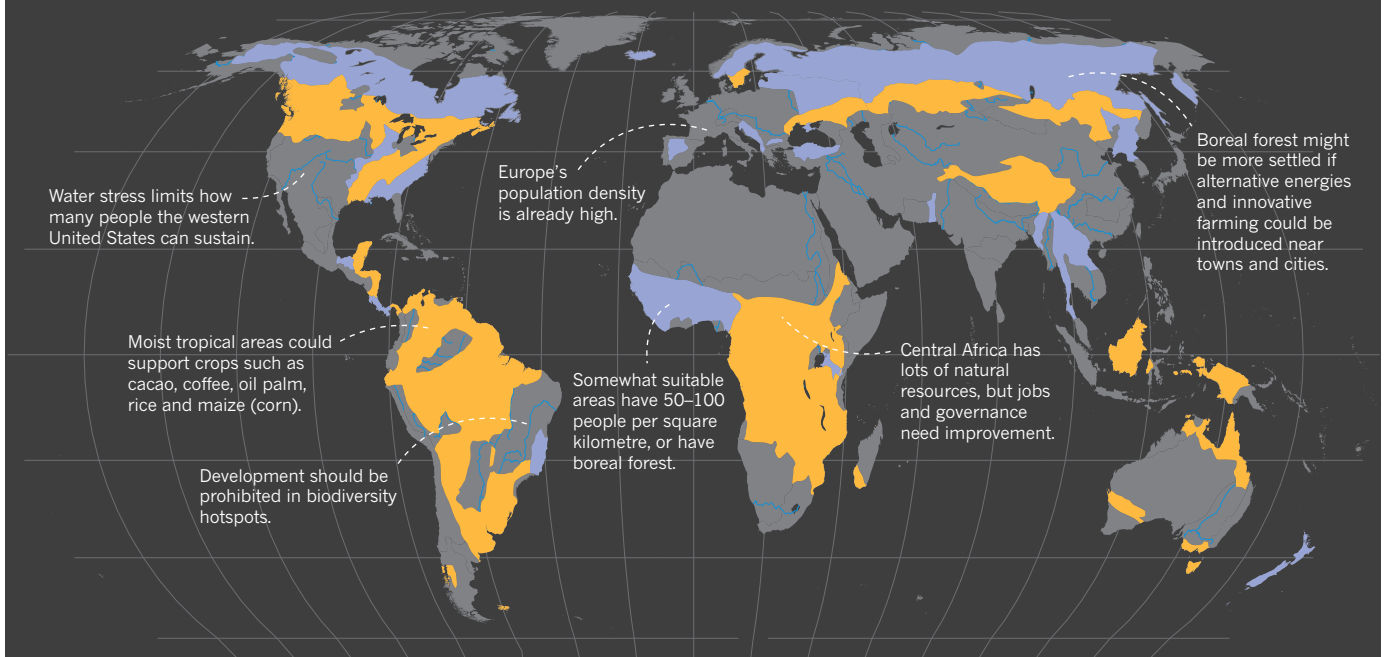
NEXT STEPS

Global-scale land planning and human migration issues should be linked to international agreements on water stress, clean

HABITABLE ZONES

Places with warm and moist climates amenable to growing crops, such as grassy and forested lands in temperate and tropical regions, could in theory sustainably accommodate more people. These include large areas of the Americas, central Africa and Asia as well as pockets of Oceania and Australia, but not populous or water-stressed regions or biodiversity hotspots.

■ Suitable ■ Somewhat suitable ■ Unsuitable



water and environmental degradation. The source and target areas of human migration should receive particular attention. Such agreements might highlight groundwater quantity and quality in urban regions; riverside or floodplain protection; and development and irrigation in areas needed to protect water supplies for cities. Immigration policies should encourage development and growth in environmentally suitable regions.

National governments must put teeth into policies mandating urban region plans. Funding for planning, implementation and measuring progress should be allocated by the different levels of government and beneficiaries.

Urban region planning requires a new mix of expertise. Essential are experts in: ecosystem and landscape ecology, water quantity and quality, agricultural soil quality and productivity, economics, transportation infrastructure engineering and community development. International agencies, non-governmental organizations, academics and professionals should step forward with case studies, examples, models and new projects. Major universities should establish multisector urban region planning units to develop models and initiatives.

Society must think globally, plan regionally, then act locally. ■

Richard T. T. Forman is a research professor at the Graduate School of Design, Harvard University, Cambridge, Massachusetts, USA. **Jianguo Wu** is the Dean's distinguished professor of sustainability science, School of Life Sciences, Arizona State University, Tempe, Arizona, USA.
e-mail: rforman@gsd.harvard.edu

1. United Nations Department of Economic and Social Affairs. *World Urbanization Prospects: The 2014 Revision* (United Nations, 2014).
2. Brinkmann, K., Schumacher, J., Dittrich, A., Kadore, I. & Buerkert, A. *Landsc. Urban Plan.* **105**, 94–105 (2012).
3. Forman, R. T. T. *Urban Regions: Ecology and Planning Beyond the City* (Cambridge Univ. Press, 2008).
4. Forman, R. T. T. *Urban Ecology: Science of Cities* (Cambridge Univ. Press, 2014).
5. Intergovernmental Panel on Climate Change. *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* (eds Stocker, T. F. et al.) (Cambridge Univ. Press, 2013).
6. Tilman, D., Balzer, C., Hill, J. & Befort, B. L. *Proc. Natl Acad. Sci. USA* **108**, 20260–20264 (2011).
7. Hoekstra, J. M. et al. *The Atlas of Global Conservation: Changes, Challenges, and Opportunities to Make a Difference* (Univ. California Press, 2010).
8. Wu, J. *Landsc. Urban Plan.* **125**, 209–221 (2014).



The Mayor of Paris, Anne Hidalgo, at a meeting of the C40 and Compact of Mayors city networks.

Give cities a seat at the top table

Building more strategic links between urban innovation and global governance will help to tackle today's grand challenges, argues **Michele Acuto**.

In October, the United Nations will launch its New Urban Agenda at the Habitat III conference on housing and sustainable urban development in Quito, Ecuador. This declaration aims to harness the power of cities as engines of sustainable development. Yet the road to Quito is uphill: cities are integrated poorly into multilateral diplomacy, and limits to their powers and budgets threaten their effectiveness as global change-makers.

Cities already account for 70% of global greenhouse-gas emissions and house more than half of humanity. Most are expanding: by the end of 2016, more than 70 million people will have moved to urban areas¹. By 2030, there will be 41 megacities of 10 million inhabitants or more, from today's 28, and city dwellers will generate more than 2 billion tonnes of waste per year².

Yet, as politically organized entities, cities are also catalysing sustainability

solutions. By 2017, for example, nearly 2.5 million daily subway commuters in Santiago, Chile, will be transported by a system run on solar and wind energy. Singapore has pioneered efficient traffic management through congestion charging since 1975. Cape Town in South Africa has some of the continent's most ambitious water-conservation targets. And San Francisco in California and Montreal in Canada have exceeded their federal governments' standards for policies on gender balance and human rights. The global importance of cities for grand challenges has been recognized in the Paris agreement on climate change, the UN Sustainable Development Goals (SDGs) and the UN Sendai Framework for Disaster Risk Reduction.

Cities are more networked than ever. They enhance their capabilities by working together, sharing experiences and forging public-private partnerships across health, governance, democracy, infrastructure ▶

➔ **NATURE.COM**
For more on cities, see:
nature.com/habitat3