# Task Force 4. Economic Effects of Infrastructure and its Financing (spillover tax). Macroeconomic evaluation and micro estimation

**Prof. and dean Naoyuki YOSHINO**, president, T20 Japan, TF4 lead co-chair, executive director, ADBI
**Amar BHATTACHARYA**, TF4 lead co-chair, senior fellow, Brookings Institution

# *The Infrastructure Nexus. From the Future of Infrastructures to the Infrastructures of the Future*

## Authors

**Nicolas J.A. BUCHOUD**, TF4 co-chair, president, the Grand Paris Alliance[1] , lead author
**Ross DOUGLAS**, executive director, Autonomy (Paris, Johannesburg), co-author
**Dr Pascal GASTINEAU**, Researcher, IFSTTAR, co-author
**Dr Martin KONING**, Researcher, IFSTTAR, co-author
**Prof. arch. David MANGIN**, EAVT Paris Marne-la-Vallée[2], co-author
**Dr Philippe POINSOT**, Associate Professor, LVMT[3], co-author
**Dr Jean François SILVAIN**, president, the Foundation for Biodiversity Research (FRB), co-author
**Dr Hélène SOUBELET**, executive director, the Foundation for Biodiversity Research (FRB), co-author

## Contributors

**Prof. Lyudmila BORILO**, executive director, Trans Siberian Scientifc Way (TSSW), National Research Tomsk State University[4]
**Kieron HENDICOTT**, executive director, Infastructure New South Wales, Australia
**Jean-Bernard KOVARIK**, TF4 co-chair, deputy CEO, IFSTTAR[5]
**Dr ass. Prof. arch. Paul LANDAUER,** EAVT Paris Marne-la-Vallée
**Luc MONTEIL**, secretary general, International Property and Biodiversity Council
**Prof. Susan PARNELL**, executive director, Centre for African Cities
**Laurent SCHMITT**, secretary general, ENSTO-E[6]
**Abel SCHUMANN**, economist, OECD
**Prof.dr.ir Arjan van TIMMEREN**, scientific director, AMS- Amsterdam, TU Delft

Final version – March 31 2019

[1] Grand Paris Alliance for Metropolitan Development (Cercle Grand Paris de l'Investissement Durable)
[2] Ecole d'Architecture de la Ville et des Territoires (EAVT) de Paris Marne-la-Vallée
[3] UPEM-LMVT. Université Paris Est Marne-la-Vallée, Mobility, Urban Planning and Transportation Laboratory
[4] TSSW. Trans Siberian Scientific Way
[5] IFSTTAR. The French Institute of Science and Technology for Transport, Development and Networks
[6] ENTSO-E. European Network of Transmission System Operators for Electricty

## Abstract

The *Infrastructure Nexus* policy-brief is a response to the call to *re-couple* economic growth and social progress, at the dawn of a global infrastructure tsunami. It highlights the lack of a definitive model of urban/metropolitan sustainability and researches on its impacts for global infrastructure and multilevel governance needs. It emphasizes that while infrastructures are forming a growingly boundless system, piecemeal approaches to developing urban sustainable agendas and projects are still prevailing, overlooking the systemic impacts of urbanisation on biodiversity and ecosystem services, which are also boundless. The first paper of a series that is to be continued, it complements the TF4 policy brief *Building Resilient Infrastructure Systems*, it advocates for a new generation of science-to-society and knowledge-to-policy connectivity to reposition infrastructure investments and value chains. In an era of rising resources limitations and urban growth, the paper outlines the underestimated role of research infrastructures in infrastructure for development policies and it proposes new priorities for a more comprehensive urban agenda within the G20, including biodiversity, with a specific focus on critical regions such as the Amazon and the Arctic.

# 1. Challenge. What infrastructures for a world of 1,000 metropolis?

In the past twenty years, the role of infrastructures to promote and sustain economic growth has been acknowledged (Calderon and Seven, 2004). After the 2008 financial crisis, infrastructure investments have been pushed as drivers for economic recovery and growth (Yifu, 2012). Sustainability has made its way in the debates between post Keynesian ecological economics and neo classics (Holt, 2010). The need for green[i] infrastructures has been emphasized, such as climate friendly railways and waterways, clean and renewable energy projects etc. (ADBI & ADB, 2008, Bielenberg et al., 2016, OECD, 2018).

Along with climate change, urbanization is the other contemporary transformative mega-trend (WBGU, 2016). It goes with metropolisation, a less studied feature of global policy-making (Katz, 2013, Ahrendt et al., 2015, Gomez et al., 2017). Contrary to the vision of a prosperous post Cold-War world of global cities (Sassen, 2001) our world is of more than 4.000 cities of +100.000 inhabitants and 1.000 metro areas of +500.000 inhabitants across the globe (UNDESA, 2016). This complex and conflicting intertwining of local and global scales is both an issue of macro- and micro economics. Many metro-regions surpass countries GDP. And yet, there is no corresponding multi-level governance (Snower, 2019).

With over 70 million more people living in urban areas annually (World Bank, 2018), investment gaps are widening, inequalities are rising (OECD, 2018), territorial and social cohesion is at risk (Fleurbaey et al., 2018). Moreover, land-use policies are massively ailing (Seto et al., 2012; Angel, Galarza et al., 2016) and the ecological footprint of human activities is rising faster than ever before (Boulding, 1966; Meadows et al., 1972; Wackernagel, 1996; Rockström, 2009; Sachs, 2015). This is the new normal for infrastructure investments, only that solid evidence about future cities -and corresponding infrastructure systems - is still to be built up.

In the absence of a clear pathway regarding optimal cityshape ensuring equality, sustainability and growth (Salat et al., 2012; Ahfeldt, 2017), communication about off-grid local experiments or the investments in designated smart urban mega projects tends to be overemphasized. In developed countries, the management costs of existing infrastructures are soaring, citizens' reluctance or resistance to new projects is growing. In low and middle income countries, the lack of infrastructures and infrastructure finance threatens long-term growth (Floater et al., 2017).

Following over a decade of loosely coordinated action and policy-making at combined micro, metro and macro-scales (Buchoud, 2019), we have reached a turning point. As illustrated by the Nationally Determined Contributions (NDCs) to reach the Paris agreement and the Voluntary National Reviews of the Sustainable Development Goals, the call for cross-sectoral approach to urbanization and infrastructure development is getting higher on local, regional and global agendas (IISD, 2017, AFD, et al., 2018). It still is to be transformed into applicable policies.

In the transition towards the decoupling of economic growth from carbon emissions (Snower, 2018), a new approach to infrastructure projects is emerging, connecting *hard* and *soft* infrastructures, infrastructure finance and users' behaviors, civil and

financial engineering, changing industry processes (WEF, 2017; Kelly, 2019) and the development of inclusive infrastructures (Mc Kinsey, 2016; IDB, 2018). Yet, two problems are not being addressed.

The first one is a confusion between *urbanization* and *urban infrastructures*. Cities and metros need infrastructures, be it about energy, mobility etc. But infrastructures serving interconnected urban areas are metropolitan, national, regional, continental, or even global. They go far beyond city limits yet with no corresponding *urban* governance at those combined scales. Hence, the quest for autonomous off-grid settlements on the one hand (Lemoine, 2014), and the development of new *geopolitical infrastructures* on the other hand, such as the One Belt One Road initiative led by China, with little left in-between.

The second problem is a chronicle deficit of knowledge about what *a global future of cities and metros* means to citizens, public and private investors, governments. It took thirty years for IPCC to build evidence, knowledge and *science-to-society* interface about climate change. At the same pace, we would have to wait until 2050 to deploy to renew *science-to-policy* partnerships in the field of urbanization, with a priority on informality, urban planning and design, green and blue infrastructures (Parnell et al., 2018). As we are touching upon limitations of natural resources and the regeneration of eco-systems is questioned (Silvain et al., 2018, Nofal et al., 2019), 2050 is way too far a horizon.

## 2. Rethinking the governance of infrastructures and urbanization

The shift towards a predominantly urban world has been formally assessed around 2005/7 (Peirce et al., 2006-8, Buchoud, 2008) but it took over a decade to start building multilateral regulatory frameworks.[ii] Meanwhile, local and regional governments, a wide range of stakeholders and interest groups from the civil society and the private sector have grasped change much more firmly than national governments. Urban growth has stirred unprecedented market-driven development opportunities in sectors such as smart cities, real estate development, creative industries which, up to a point, has blurred the lines between the general interest and the promotion of embodied interests (Peck, Tickell, 2002; Larner, Laurie 2010; McCann et al., 2013; Raco, 2013).[iii] The formation of new knowledge out of interdisciplinary strategies has been comparatively very slow (Revi et al., 2018) and weak.

Since the turn of the millennium, many cities have engaged in long-term visioning exercises, with infrastructure planning as a key. From New-York to Tokyo, Sydney to London, Moscow to Shanghai, Singapore to Paris, the UAE or recently Saudi Arabia, such *grand* plans have led to the adoption of significant investment packages. A number of cities in India, South-East Asia or Central Asia are now following the way. Despite the lack of reliable and internationally comparable data and the routine presence of lagging indicators (Leff, Petersen, 2015), the *Greater Paris* or *Greater Moscow*, the *New-York* or *London Plan*, etc… nurtured an overall impression of progress and a new literature about *Mayors Ruling the World* (Barber, 2013).

Yet, the promotion of innovation and the development of new large scale mobility systems have not prevented a global systemic decline in housing affordability (UN

Habitat, 2018, Schumann, 2019). The governance of complex metro areas is generally weak (Lanfranchi et al., 2017) and the adverse effects of infrastructure development on spatial inequalities underestimated (Combes and Lafourcade, 2011, Fingleton and Szumilo, 2019). The connectivity between investments in large scale infrastructure projects and the building of social capital has been neglected by neo-classics and post-Keynesian economics.[iv]

There is a failure in the promotion of compact urban development models.[v] Apart from questionable success stories such as the densification of Vancouver downtown, contemporary urban growth consumes three times more land per capita than in the 1990's (Angel, Galarza et al., 2016), which is true in all parts of the world.[vi]

Unregulated urban growth is the cradle of urban financial success stories bringing hope but also confusion. According to McKinsey, $110 billion has been invested in mobility startups between 2010 and 2016 with most of it going to startups in the sharing and autonomous vehicle spaces and the bulk of the investment coming out of Silicon Valley.[vii] The global venture capitalist community has been looking for the next big opportunity and believed it to be mobility (not infrastructures), causing systemic disruptions in urban governance, infrastructure finance and planning models.[viii] The stock-exchange value of ride-hailing companies now often exceeds some of the largest infrastructure investment packages across the globe.[ix]

Subsidized public transit has long been a preferred way to move large flows of people at low levels of pollution and congestion per capita. Many promising mobility models now reflect an individualization of travel (Schwanen, 2016) with *apps* and *fleets* of cheap light electric vehicles and devices to move people as effectively at much lower costs.[x] In the United-States, public transit ridership figures are already declining. Should cities forego massive infrastructure spending and repurpose roads and parking bays for new free-floating fleets? To what extent new technologies can replace complex transport infrastructures is unknown as no city has been able to reduce car ownership significantly enough to test the hypothesis.[xi]

Many changes in infrastructure development and management are under way, from integrated multimodal infrastructures (Ambrosino et al., 2003) to multirole infrastructures combining mobility and energy systems (Hautière et al., 2013; Cirimele et al., 2016, Crozet and Koning, 2019). Intelligent Transport Systems (ITS) are promising ways to review infrastructure pricing and favor clean transport (Harris et al., 2015; Cramton et al., 2018; Schuitema and Steg, 2018; Koning et al., 2019).[xii] Yet, the upscaling of such sets of solutions require multi-level urban governance systems which are missing. As of today, divided urban systems are commonplace, in lieu of harmoniously networked urban mangroves (Mangin, Girodo, 2016).

In Japan as well as in many other areas of the globe, the need for *quality infrastructures* (Runde, 2017, 2019; Nakamura et al., 2019) to respond to climate change mitigation and adaptation and meet with societies needs is much asserted. Yet, the obstacles on the way to sustainability have silently piled up : multilateral frameworks about climate, cities, development and growth, came up as deep transformations of the economy, the society, and the environment were already well on their way.[xiii] This calls for a revised approach of infrastructure development.

## *3.* Reviewing *research infrastructures* as a cornerstone of infrastructures for development

A global infrastructure Tsunami (Laurance, 2018) is bound to expand around the world as urbanization continues, with more than 25 million km of new roads by 2050. As of today, the Earth's surface is split in more than half a million patches. With investments in development and new infrastructures squeezing biodiversity (Ibisch; IUCN et al., 2016), we are way behind the targets set up by at the Aichi 2010 world conference on biodiversity (Watson, IPBES, 2018, Silvain et al., 2018). [xiv]

Only a small number of studies have really quantified the relationships between biodiversity and various ecosystem services over time (Laurance et al., 2017, Choi et al., 2018).[xv] The private sector shows a growing interest in biodiversity offset policies but the process remains complex (Levrel et al., 2012, Global Inventory of Biodiversity Offset Policies, 2019).

Strategic features of environmental impact assessments (EIAs) such landscape fragmentation mitigation remain weak. *Strategic environmental assessments* (SEAs) and *strategic land-use planning* bring some advantages over EIAs but they are far from being the new normal (Laurance, Burgués Arrea, 2017).

We know little about the design of cities, roads and other infrastructures to minimize their ecological footprint. Finding the best development patterns to limit the adverse impacts of urbanization on ecological connectivity is crucial. Harmonized regional and global scale analysis to measure the *co-benefits* between biodiversity and the sustainable design and management of infrastructures is missing (Soubelet et al., 2019).

Large scale and long term big data analysis and modelling is the only way to anticipate the impacts of ecosystems degradation and biodiversity losses, to build urban environment plans at local and global levels, including biodiversity tradeoffs, to limit the risks of infrastructure failures.

The contemporary global biodiversity crisis highlights the deficit of globally coordinated research infrastructures (Silvain, 2018, Barot et al., 2018), whereas the gradient of systemic complexity is exponentially rising from infrastructure development issues, to urbanization, to Earth system.

Change factors exist. Research can help understand how infrastructures can be beneficial for biodiversity in an Earth system perspective. Research on urban metabolism and circular economy (Fernandez, 2013, Van Timmeren, 2015) is changing infrastructures impact assessments. Within G20, several countries are implementing new comprehensive national research strategies focusing on Earth System (Cornell et al., 2012, Biermann, 2014, Latour, 2017). Yet, the collaboration among national systems remains prone to chronical instability due to short project-finance cycles and to the lack of cross-sectoral research on biodiversity and urbanization.[xvi]

The reinforcement of a global agenda on biodiversity could be durable game changer in research with numerous impacts in the economy (Soubelet et al., 2019).

## Recommendations for T20 Japan legacy

Regional and cross-continental integrated and smart infrastructures systems are emerging such as with power grids built on long-term forecasts by 2040 (ENTSO-E, 2018) 2050 or beyond. This provides an interesting model for the development of a new generation of scientific and research infrastructures, as centralized and distributed networks working at micro and macro scales on combined physical installations and virtual connections.

The focus of the international community on large scale research infrastructures is nothing new (OECD, 1992 to 2010, Belmont challenge, 2009, 2011) but it has to be broadened. In the 18th century, major endeavors such as the Great Northern Expedition mobilized hundreds of scientists from different countries along existing mapping and infrastructures. They nurtured the creation of new routes and new knowledge and contributed to the formation of modern science.

To address the pressing knowledge gaps of the 21st century highlighted in the present paper, we propose to include in T20 priorities a focus on large scale research infrastructures [xvii] and to foster a fast-track approach connecting infrastructure development, urbanization governance and Earth System theories and research programs.

We recommend to enrich and deepen the T20 infrastructure agenda by:

- connecting with the emerging IPCCcities and with the U20 engagement group of G20
- building a dialogue between long term research strategies across G20 members
- reflecting on key proposals such as the creation of a global fund for biodiversity, complementing climate finance

The *One Planet Summits*, the project of a *Global Pact for the Environment*, the SDSN, the preparation of 2020 *IUCN Congress* and *COP15 Biodiversity* in Kunming could serve as catalysts.[xviii]

In that context, we view the transformation and development of the Amazon as well as of the Arctic and circumpolar regions as issues for T20 infrastructure agenda, in a vary rapidly changing context.[xix] If the combination of a natural and geo-science focus with an infrastructure and urban focus is not managed properly, the risk is that such critically changing regions become areas of ruthless competition only, in lieu of places to cooperate for the long-term management of our urbanizing planet.

# References


ACUTO Michele, PARNELL Susan, SETO Karen C. and CONTESTABILE, Monica, ed. *Science and the Future of Cities. Report on the Global State of the Urban Science Policy Interface. Expert Panel on Science and the Future of Cities.* International Science Council, UCL Grand Challenge of Sustainable Cities, University of Melbourne's Faculty of Architecture, Building and Planning, Melbourne School of Design, The Prince of Wales's Charitable Foundation International Sustainability Unit, 55 p., 2018,

ADB and ADBI. *Infrastructures for a Seamless Asia.* Tokyo, 282 p., 2009

AHLFELDT, Gabriel; PIETROSTEFANI, Elisabetta. *Demystifying Compact Urban Growth: Evidence form 300 Studies from Across the World.* OECD, Climate for Urban Transitions. A New Climate Economy Special Initiative. 84 p., 2017

AKHMOUCH, Aziza (dir.), OECD. *Inclusive Growth and Social Cohesion in Cities: an OECD Approach.* Urban 20 White Paper, 35 p., 2018

AMBROSINO, G., NELSON, J.D. and ROMANAZZO M. (eds.) *Demand Responsive Transport Services: Towards the flexible Mobility Agency*. ENEA – Italian National Agency for New Technologies, Energy and the Environment, 332 p., 2003

ANGEL, Schlomo; BLEI, Alejandro M.; PARENT, Jason; LAMSON-HALL, Patrick; GALARZA-SANCHEZ, Nicolas, ed. *The Atlas of Urban Expansion. The 2016 Edition. Volume I: Areas and Densities.* NYU Urban Expansion Program at New York University, UN-Habitat, and the Lincoln Institute of Land Policy, 500 p., 2016

Asian Development Bank, Asian Development Bank Institute. *Infrastructures for a Seamless Asia.* A joint study, 251 p., 2009

Belmont Challenge (the). *A Global, Environmental Research Mission for Sustainability*. 3 March 2011, Final version. 17 p. Revised version, Oct. 2016

BAROT S., SARRAZIN F., SOUBELET, H., SILVAIN, JF. *Le monde de demain dépend de la recherche actuelle sur la biodiversité.* La Croix, 23 mai 2018

BIELENBERG, Aaron; KERLIN, Mike, OPPENHEIM, Jeremy, ROBERTS, Melissa. *Financing change: How to mobilize private-sector financing for sustainable infrastructure.* McKinsey Center for Business and Environment, 62 p., Jan. 2016

BIERMANN, Franck. *Earth System Governance: World Politics in the Anthropocene*. MIT, 320 p., 2014

Blended Finance Taskforce. *Better Finance, Better World. Consultation Paper of the Blended Finance Taskforce.* Business and Sustainable Development Commission and SYSTEMIQ, 119 p., April 2018

BRINK, Lindsey and TELES, Steven. *The Captured Economy. How the Powerful Become Richer, Slow Down Growth, and Increase Inequality*. Oxford University Press, 211 p., 2017

BROEKHOVEN (van), Saskia and VERNAY, Anne-Lorène. *Integrating Functions for a Sustainable Urban System: A Review of Multifunctional Land Use and Circular Urban Metabolism.* Sustainability Review, 24 p., June 2018

BUCHOUD, Nicolas J.A and PHAN, Lan-Phuong. *Smart Cities, from Infrastrucutres to Social K?* IBA Heildelberg, ed. In *IBA Lab 6. Die Wissenstadt von Morgen,* 2019

BUCHOUD, Nicolas J.A. *Education 5.0, towards the Anthropocene? Space, Knowledge, Progress, Siberia and the Digital Age. Inaugural lecture of the National Research Tomsk State University Center for Urban Studies and Regional Development,* April 2017

BUCHOUD, Nicolas J.A. *Villes versus Finance ? Incertitudes, tenisons et opportunités à l'heure des ODD.* In Réflexions Immobilières, n°85, 3ème trimestre 2018

BUCHOUD, Nicolas J.A.; GROSSENBACHER, Danielle, ed. *The Affordable Metropolis Initiative. A Global Policy Dialogue on Affordable Housing. Policy, Finance, Technology and Shelters.* Cercle Grand Paris de l'Investissement Durable, FIABCI, GAP, Paris- New-York, 34 p., Dec. 2018

Business and Sustainable Development Commission. *Better Business, BetterWorld. The Report of the Business and Sustainable Development Commission*, 119 p., Jan. 2017

CALDERON, César; SERVEN, Luis. *The Effects of Infrastructure Development on Growth and Income Distribution.* Policy Research Working Paper; No.3400. World Bank, Washington, D.C. https://openknowledge.worldbank.org/handle/10986/14136 License: CC BY 3.0 IGO.

CARLINI, Enrico Maria, SCHROEDER, Robert, BIRKEBAEK, Jens Moller, MASSAR, Fabio. *EU transition in power sector. How RES affects the design and operations of transmission power systems.* Electric Power Systems Research, 169 , pp. 74-91, 2019

CHEVALIER, Ophélie; LARRUE, Clément; CASTILLO, Martha, et al. *Implementing the Paris Agreement on the local Level. A Framework Proposal to Foster Vertical Integration in NDCs*. The French Development Agency (AFD), Development Bank of Latin America (CAF) and Inter-American Development Bank (IDB) contribution to the U20 process. Urban 20 White Paper, 33 p., 2018

CHOI, Chi-Yeung, *et al. Biodiversity and China's new Great Wall.* Diversity and Distributions. 24, pp., 137-143, 2018

CIRIMELE, V., FRESCHI, F. and MITOLO, M. *Inductive power transfer for automotive applications: State-of-the-art and future trends*. Industry Applications Annual Meetin, IEEE, 2016

CLUZET, Alain. *Le Grand Paris. L'accélération du monde.* Infolio ed., Paris.187 p., 2017

COMBES, Pierre-Philippe; LAFOURCADE, Miren. *Competition, market access and economic geography : Structural estimation and predictions for France*. Regional Science and Urban Economics, 41(6), pp. 508-524, 2011.

CONTRERAS CASADO, Cristina; ZUNIGA, Mariana C. Silva. *Upstream planning for sustainable Infrastructure Projects.* Urban 20 White Paper, IDB, IDB, 26 p., Dec. 2018

CRAMTON, P., GEEDES, R.R. and OCKENFELS, A. *Set road charges in real time to ease traffic.* Nature, 560, 23, 2018

CROZET, Y. and KONING, M. *Les effets externes des transports : Définition, évaluation et implications pour les politiques publiques*. Rapport pour le Conseil Scientifique de TDIE, 2019

ENTSO-E. Europen *Power System 2040. Completing the map. The Ten-Year Network Development Plan,* 52 p., 2018

ENTSO-E. *Technologies for Transmission System.* 21 p., 2018

ESPEY, Jessica; REVI, Aromar. *Translation Global Vision into Local Reality: Building the right knowledge and policy infrastructure to support local sustainable development.* Urban 20 White Paper. An SDSN contribution to the U20 process, 27p., Dec. 2018

EUBANKS, Virginia. *Automating inequality: How High-Tech Tools Profile, Police and Punish the Poor.* St Martin's Press, 2018

FERNANDEZ, John E.; FERRAO, Paulo. *Sustainable Urban Metabolism.* MIT Press, 264p., 2013

FINGLETON, Bernard; SZUMILO, Nikodem. *Simulating the impact of transport infrastructure investment on wages : A dynamic spatial panel model approach*. Regional Science and Urban Economics, 2019, in press.

FLEURBAEY, Marc (dir.). *Manifeste pour le progrès social.* La Découverte, Paris, 287 p., 2019

FLOATER, Graham; DOWLING, Dan, CHAN, Denise et al. *Global Review of Finance For Sustainable Urban Infrastructure.* Coalition for Urban Transition. A New Climate Economy Special Initiative. LSE Cities, PWC, 43 p., Dec. 2017

FLOATER, G., RODE, P. (ed). *Cities and the New Climate Economy: the transformative role of global urban growth.* New Climate Economy Cities Paper 01. LSE Cities, London School of Economics and Political Science, 70 p., 2014 (2015 deposited, latest review 2019)

FORNI, Marc. *Mind the gap: How bringing together cities and private investors can close the funding gap for urban resilience.* The World Bank Sustainable Cities, April 2018

FOUCHER, Michel (dir.) *L'Arctique. La nouvelle frontière.* CNRS Editions, Paris, 172 p., 2014

FU, Wei; TURNER, Jonathan C., ZHAO, Junquan, DU, Guozhen. *Ecological footprint (EF): An expanded role in calculating resource productivity (RP) using China and the G20 member countries as examples*, 2014

GAO, Jixi; TIAN, Meirong. *Analysis of over-consumption of natural resources and the ecological trade deficit in China based on*

*ecological footprints.* Ecological Indicators, Vol. 61, part 2, pp. 899-904, Feb. 2016

LEVREL, Harold; HAY, Julien ; BAS, Adeline; GASTINEAU, Pascal; PIOCH, Sylvain. *Coût d'opportunité versus coût du maintien des potentialités écologiques : deux indicateurs économiques pour mesurer les coûts de l'érosion de la biodiversité.* Natures Sciences Sociétés, vol. 20, pp. 16-29, Juillet 2012

GOMEZ, David; LANFRANCHI, Gabriel; MORENO, Eduardo; RAJACK, Robin ed. *Steering the Metropolis. Metropolitan Governance for Sustainable Urban Development.* IDB, CAF, UN Habitat, CIPPEC, 172 p., 2017

GORDON, Ascelin, BULL Joseph, WILCOX, Chris, MARON M. *Perverse incentives risk undermining biodiversity offset policies.* Journal of Applied Ecology, 52(2), pp. 532-537, 2015

GOSSLING, S. *ICT and transport behavior: A conceptual review*. International Journal of Sustainable Transportation, 12(3), pp. 153-164, 2018

GOSSLING, S., SCHRODER, M., SPATH, P. and FREYTAG, T. *Urban space distribution and sustainable transport.* Transport Reviews, 36(5), pp. 659-679, 2016

GRAUWE (de), Paul. *De limitien van de markt.* Uitgeverij Lannoo, 2014, 240 p. *The Limits of Market. The Pendulum between Government and Market.* Oxford University Press, 159 p., 2017

GRIFFITHS, Victoria, BULL, Joseph, BAKER, Julia, MILNER-GULLAND E.J. *No net loss for people and biodiversity.* Conservation Biology, 33(1), pp. 76-87, 2018.

HARRIS, I., WANG, Y. and WANG, H. *ICT in multimodal transport and technological trends: Unleashing potential for the future,* International Journal of Production Economics, 159, pp. 88-103, 2015

HAUTIERE, N., DE LA ROCHE, C., JACQUOT-GUIMBAL, H. *La route de cinquième génération : quelle infrastructure dans vingt ans et quels services en attendre* ? Revue Générale des Routes et de l'Aménagement, 910, 2013

HERAN, F. and RAVALET, E. *La consummation d'espace-temps des divers modes de déplacement en milieu urbain. Application au cas de l'Ile-de-France.* Rapport de recherche pour le GO1 du PREDIT, 188 p., 2008

HERWEJER, Celine (forewaord), PWC. *Harnessing the Fourth Industrial Revolution for Sustainable Emerging Cities.* In collaboration with PWC and Stanford Woods Institute for the Environment. World Economic Forum, Fourth Industrial Revolution for the Earth Series, Nov. 2017, 22pp.

HOLT, Richard P.F., PRESSMAN, Steven & SPASH, Clive, L. (eds). *Post Keynesian and Ecological Economics: Confronting Environmental Issues*. Edward Elgar, Northampton, MA, 352 p., 2010

HRUSAK, Jan (ed) et al. *Long-Term Sustainability of Research Infrastructures.* ESFRI - European Strategy Forum on Research Infrastructures Long-Term Sustainability Working Group. Published by Dipartimento di Fisica - Università degli Studi di Milano, October 2017

IBISCH, PL; et al. A global map of roadless areas and their conservation status. Science. 2016 Dec 16; 354(6318) pp. 1423-1427.

IPCCcities 2018. VENTIMIGLIA, Andrea (editing*). Global Research and Action Agenda on Cities and Climate Change Science,* 8 p., 2018

KATZ Bruce and BRADLEY Jennifer. *The Metropolitan Revolution. How Cities and Metros Are Fixing Our Broken Politics and Fragile Economy.* Brookings Institution Press, 288 p., 2013

KENNEDY, R; ZAPASNIK, J; MCCANN, H et al. *All Those Little Machines: Assemblage as Transformative Theory.* Australian Humanities Review, vol. 55, no. pp. 45 – 66, 2013

KONING, M., COMBES, F., COULOMBEL, N. *Welfare losses caused by underpriced and heterogeneous road transport: The Paris region case study.* IFSTTAR Working paper, 2019

KOURTIT, K., NIJKAMP, P. and STEENBRUGGEN, J. *The significance of digital data systems for smart city policy*. Socio-Economic Planning Sciences, 58, pp. 13-21, 2017

KRAWCHENKO; SCHUMANN, Abel; TAMARA. *The Use of Land: Why Planners Cannot Go for it Alone.* OECD Observer, n° 307, Q3 2016

KUHN, Thomas S. *La structure des révolutions scientifiques.* Champs Sciences, Flammarion 277 p., Mars 2018

LANDAUER, Paul, *Grands ensembles, terres d'avenir.* EcologiK, numéro spécial *« Pavillon français de la Biennale de Venise, 2012 »,* pp.40-43, 2012

LANFRANCHI, Gabriel, HERRERO, Ana Carolina, FERNANDEZ, John E. Massachusetts Institute of Technology (MIT) ROJAS, Francisca Inter-American Development Bank (IADB) TROSTMANN, Katerina, *Enhancing climate resilience through urban infrastructure and metropolitan governance.* T20 Argentina, 13 p., 2018

LARNER, Wendy ; LAURIE, Nina. *Travelling technocrats, embodied knowledges: Globalising privatisation in telecoms and water.* Geoforum, Vol. 41, No. 2, pp. 218-226, March 2010

LATOUR, Bruno. *Où atterrir ?. Comment s'orienter en politique,* La Découverte, 111 p., 2017

LAURANCE, William F. ; BURGUÉS ARREA Irene. *Roads to riches or ruin? Global infrastructure expansion must balance social benefits and environmental hazards*. Science, 358 (6362), pp. 442-444, 2017

LAURANCE, William F. *Conservation and the Global Infrastructure Tsunami: Disclose, Debate, Delay!* Trends in Ecology & Evolution 33(8): pp 68-571, 2018

LAURANCE, William F., et al. *Road Expansion and the Fate of Africa's Tropical Forests*. Front. Ecol. Evol. pp. 5-75, 2017

MANDLE, Lisa, TALLIS, Heather, SOTOMAYOR, Leonardo, VOGL Adrian. *Who loses? Tracking ecosystem service redistribution from road development and mitigation in the Peruvian Amazon.* Frontiers in Ecology and the Environment 13(6), pp. 309-315, 2015

MANGIN, David ; GIRODO, Marion. *Mangroves urbaines, du métro à la ville. Paris, Montréal, Singapour.* La Découverte, 308 p. 2016

MANGIN, David. *La ville franchisée.* Editions de la Villette. 400 p., 2004

NAKAMURA, Ideo et al. *Principles of High Quality Infrastructure. Case studies and best practices.* ADBI, Mitsubishi Research Institute, 2019

NATIVI, Stefano, et al. *Earth Science Infrastructures Interoperability: The Brokering Approach.* IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing, Volume: 6 , Issue: 3 , June 2013

NICOLUCCI, V.; TIEZZI, E.; PULSELLI, F.M.; CAPINERI, C. *Biocapacity* vs *Ecological Footprint of world regions: A geopolitical interpretation.* In Ecological Indicators, 2012

OECD, World Bank Group, UNEP. *Financing Climate Futures. Rethinking Infrastructures,* 136 p., Nov. 2018

OECD*. International Distributed Research Infrastructures. Issues and Options*, 25 p., 2014,

PECK, Jamie; TICKELL, Adama. *Neoliberalizing Space.* Antipode, a Rdical Journal of Geography, pp. 380-404, Dec. 2002

PEIRCE, Neal R; JOHNSON, Curtis W et al. *Century of the City. No Time to Lose.* The Rockefeller Foundation, 447 p. 2008

PILLING, David. *The Growth Delusion. The Wealth and Well-Being on Nations.* Bloomsbury, 2018

PINEDA, Emilio; KAMIYA, Marco; Radda, Kristtian; SOUCHET, Louis-Antoine. *Promoting Subnational Financing for Cities.* Urban 20 White Paper. A French Development Agency (AFD), International Finance Corporation (IFC), The United Nations Human Settlements Programme (UN–Habitat) and Inter-American Development Bank (IDB), 23 p., Dec. 2018

PRASSL, Jeremias. Humans as a service. T*he Promise and Perils of Work in the Gig Economy.* Oxford University Press, 191 p., 2018

RACO, Mike. *Delivering Flagship Projects in an Era of Regulatory Capitalism: State-led Privatization and the London Olympics 2012.* International Journal of urban and Regional Research, Vol. 38.1, pp. 176-197, Jan. 2014,

RUNDE, Daniel F. *Quality Infrastructure: Ensuring Sustainable Economic Growth,* Center for Strategic and International Studies, CSIS, 6 p., Jan. 2017

SACHS, Jeffrey. *The Age of Sustainable Development*. Columbia University Press, 2015

SASSEN, Saskia. *The Global City. New York, London,* Tokyo. Princeton University Press, 480 p., 2001

SCHWANEN, Tim. *Innovations to Transform Personal Mobility.* In HOPKINS, D., and HIGHAM, J. (ed). *Low Carbon Mobility*

*Transitions,* Oxford, Goodfellow Publishers, 2016

SCHUITEMA, G. and STEG, L. *Road charges in real time are not a silver bullet.* Nature, 564(7734), 39, 2018

SILVAIN, Jean-François ; SOUBELET, Hélène; SARRAZIN, François, BAROT, Sébastien; BOUGRAIN-DUBOURG, Allain; LESIGNE, Jean-François; LAURANS, Yann. *La lutte contre l'érosion de la biodiversité doit être une priorité internationale*. Le Monde, 10 Jan. 2018

SILVAIN, Jean-François. *Un aperçu – subjectif – de la recherche sur la biodiversité. Septembre 2017-décembre 2018.* Fondation pour la recherche sur la biodiversité-FRB, 42 p., Dec. 2018

SKYLER, Ed. *A Conversation with Cities: Mayors on Closing Gaps in Infrastructure and Economic Opportunity.* City Accelerator, an initiative of CITI, CITI Foundation, Oct. 24 2017.

SNOWER, Dennis, J. *Toward Global Paradigm Change. Beyond the crisis of the liberal world order.* Global Solutions Journal, Issue 4, 2019, pp. 12-32, March 2019

SNOWER, Dennis, J., ENGELS, Markus, ed. *Recoupling.* Volume 1, Issue 2. G20/T20 Argentina 2018, Special. Global Solutions Journal, 282 p., 2018

SOUBELET, Hélène., SILVAIN, Jean-François., DELAVAUD, A. *Diminuer notre empreinte écologique en préservant la biodiversité. Une grande cause nationale.* Fondation pour la recherche sur la biodiversité-FRB, 12 p., Mars 2019

T20 Summit 2018. *T20 Communiqué.* T20 Argentina, 85 p., 2018

TARGA, Felipe; MOOSE, William; ESTUPIAN, Nicolas; MOJICA, Carlos. *Urban Mobility, Health and Public Spaces: Reshaping Urban Landscapes.* Urban 20 White Paper, 36 p., 2018

The Global Commission on the Economy and Climate. *Seizing the Global Opportunity. Partnerships for Better Growth and a Better Climate.* The 2015 New Climate Economy Report, 75 p., 2015

The Global Commission on the Economy and Climate. *The Sustainable Infrastructure Imperative. Finance for Better Growth and Development.* Key messages and Executive Summary, 2016

TIMMEREN (van), Arjan. *GreenBlue Infrastructures for Sustainable, Attractive Cities.* Tokyo University, March 4th 2015 (presentation)

UNEP Finance Initiative, United Nations Global Compact. *SDG Bonds and Corporate Finance. A Roadmap to Mainstream Investments*, 43 p., 2018

UNEP Finance Initiative. *Rethinking Impact to Finance the SDGs. A Position Paper and Call to Action prepared by the Positive Impact Initiative,* 48 p., Nov. 2018

UNEP Finance Initiative. *The Impact Radar/ A Tool for Holistic Impact Analysis. Principles for Positive Impact Finance.* 16 p., Nov. 2018

UZSOKI, David. *Tokenization of Infrastructure. A blockchain-based solution to financing sustainable infrastructure.* IISD, MAVA, 34 p., Jan. 2019

WACKERNAGEL, M., Rees, W.E., 1997. *Perceptual and structural barriers to investing in natural capital: economics from an ecological footprint perspective.* Ecological Economics, Vol. 20, Issue 1, pp. 3-24, Jan. 1997

WACKERNAGEL, Mathis; REES, William E. *Our Ecological Footprint: reducing human impact on the earth.* Gabriola Island, BC; Philadelphia, PA: New Society Publishers, 160 p., 1996

WAGNER, Hermann-Friedrich (dir.). OECD Large research infrastructures. *Report on Roadmapping of Large Research Infrastructures* (2008) and *Report on Establishing Large International Research Infrastructures: Issues and Options* (2010), 40 p.

WBGU – German Advisory Council on Global Change. *Humanity on the Move: Unlocking the Transformative Power of Cities.* WBGU, 2016, 544pp. https://www.wbgu.de/en/fr2016/

WIEL, Marc. *Grand Paris, vers un plan B.* La Découverte, 420 p., Paris, 2015

YIFU LIN, Justin; DOMELAND, Doerte. *Beyond Keynesianism. Global Infrastructure Investments in Times of Crisis.* Policy Research Paper 5940. The World Bank Office of the Chief Ecoinomist, 40 p., Jan. 2012

YOSHINO, Naoyuki, HEBLE, Matthias, ABIDHADJAEV, Umid, ed. *Financing Infrastructure in Asia and the Pacific. Capturing Impacts and New Sources.* Asian Development Institute – ADBI, 488 p., 2018

# Notes

[i] *Green Infrastructures* refer to interventions to preserve the functionality of existing green landscapes (including parks, forests, wetlands, or green belts), and to transform the built environment through phytoremediation and water management techniques and by introducing productive landscapes (IPCC 2014b). This can be termed blue infrastructure if aquatic ecosystems are concerned (European Environment Agency 2017). Source: *Global Research and Action Agenda on Cities and Climate Change Science, 2018*

[ii] The adoption of the United Nations Agenda 2030, including the Sustainable Development Goals (SDGs) and SDG11 on "sustainable, safe and resilient cities and communities" took place in the fall of 2015. The Paris 21st Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC) setting up new goals to mitigate climate change and curb CO2 emissions also took place in the fall of 2015. The Habitat III Summit which issued the New Urban Agenda took place in Quito a year later in 2016. The rise of a global agenda on biodiversity is only happening now, with the 15thmeeting of the Conference of the Parties to the Convention on Biological Diversity (COP15) to be hosted by China in 2020.

[iii] Real estate markets should account for more than US$ 4,3 trillion by 2025 (Grand View Research Inc, 2018) and yet the affordability gap is ceaselessly growing, estimated at more than US$ 650 billion per year (UN Habitat, 2018). Depending on sources, the global smart cities markets should account for more than US$ 2 trillion per year (Frost & Sullivan, 2018) to US$ 3,5 trillion per year (Research and Markets, 2017) by 2025. Yet, there is little evidence that internet 3.0, IoT, industry 4.0... are self-help drivers for inclusive territorial development (Eubanks, 2018, Temin, 2017). While in cities and regions across the globe, citizens are struggling with congested mobility systems, social networks, design, television and cinema, literature, including cartoons and mangas, are boiling with anticipation and science fiction, all about cities and their future virtual and physical infrastructures. Creative industries as a whole shape global (urban) imaginaries worldwide with a market of more than US$ 2 trillion per year (PWC, 2015, WCCE, 2018).

[iv] A recent survey in 347 districts of England and Wales shows that while multi-billion pound investments in high-speed rail increased averages wages by 2% in the region, its impacts on districts was quite heterogeneous and sometimes negative (Fingleton and Szumilo, 2019).

[v] Despite the invention of Transit Oriented Development (Calthrope, 1993), the number of motorized vehicles and especially private cars in the world is expected to reach 1,5 billion in 2020, out of 675 million in 1990 (Sperling and Gordon, TRB, 2009, UNECE, 2015).

[vi] There is a high probability (> 75 %) that large areas of the European continent totaling approximately 77.500 km2, that is the equivalent of the total surface of Belgium and the Netherlands together, will be or have been converted to urban areas between 2000 and 2030 (Seto et al., 2012).[vi]

[vii] Investments are also coming from China and South-East Asia now.

[viii] Uber has raised a total of $24 billion in over 22 rounds and hopes to go public in summer 2019 at a valuation of $120 billion. But the company has challenges. It is burning through cash (in the second quarter of 2018, it lost $891 million) and has increasing competition due to low barriers to entry. Cities are also starting to question their offer of "let us fix your urban mobility problems". New York was the first major city to limit the number of vehicle licenses after a study reported that Uber was contributing to traffic. In Germany, Uber was briefly banned in 2014, and currently only operates in Berlin, Munich, Düsseldorf and Frankfurt. Uber's vision is to be the world's first private multi-modal operator moving commuters by bike, car, air taxi and autonomous vehicle in the future. Whether this is a vision shared by the public and cities alike, only time will tell.

[ix] As of 2018, the total market value of the world's largest global ride-hailing companies was about US$ 100 billion, a calculation is based upon the market value of the companies Lyft, Grab, GoJek and Uber as of December 2018. Uber stock-exchange market value alone was worth US$ 71 billion in 2018, which is more than the combined total investment costs for the London Crossrail project (circa US$ 20,1 billion, source GLA 2018) and the Grand Paris Express metro network serving the Greater Paris metro area by 2030 (circa € 38 billion or US$ 43 billion, source Société du Grand Paris, 2018), two of the world's largest metropolitan transportation infrastructure projects. Not only are large scale infrastructure projects costly to finance.

[x] The demand for public transport in America continues to decrease as Americans prefer to spend time in their car alone than use mass transport. Transit ridership fell in 31 of 35 major metropolitan areas in the US in 2017 (Washington Post).

[xi] Paris, which has low car use, has 150 000 parking bays at street level that could potentially be repurposed into lanes for new mobility (Héran and Ravalet, 2008; Gössling et al., 2016).

[xii] Alternatively, integrated infrastructures may support the implementation of « quantity based regulation ». Assume that each citizen or economic agent is endowed with a given amount of "mobility permits", defined consistently with the maximal volume of transport-related negative externalities to be emitted (e.g. GHG or local pollutants quotas), but also with social considerations (e.g. people living in depraved areas, far away from the city center, receive more permits). An integrated and ICT-based

interface between the users and the transport infrastructures could be an efficient way to implement and to monitor the system (your permits' account will be debited differently if you're using subways, bikes or cars; for 1 or for 10 kms), as well as to organize a market where economic agents who have an excess volume of permits could sell them to those who need to travel (and to pollute) more.

[xiii] Proposals such as the *Planetary Boundaries* (2009) or the reinforcement of the *Anthropocene Theories* (2009, 2016) offer new horizons for a more holistic approach to current global transformations but they have remained mostly conceptual.

[xiv] An unprecedented spate of road building is happening, with around 25 million km of new paved roads expected by 2050, according to a global comprehensive survey disclosed in 2016 and led by Pierre Ibisch at Eberswalde University for Sustainable Development, Germany. He attempted to map all of the roads and remaining ecosystems across Earth's entire land surface. Its headline conclusion is that roads have already sliced and diced Earth's ecosystems into some 600,000 pieces. More than half of these are less than 1 square km in size. Only 7% of the fragments are more than 100 square km. A quick look at OpenStreetmap also shows that cities are far better mapped than hinterlands. For instance, in the Brazilian Amazon, P.Ibisch colleagues recently found 3km of illegal, unmapped roads for every 1km of legal, mapped road. Source: *The Global Road Building is Shattering Nature*. The Conversation, Dec. 2016.

[xv] According to a global survey of the latest research literature on biodiversity in 2018/2018 (Silvain, 2018), few studies have explored the spread of invasive species in relationship to transportation network. Our understanding of alien species distribution at large spatial scale in combination with spatial modelling procedures is weak. There are also key research gaps regarding the impact of infrastructures related to tourism and recreation. This is particularly true in southern most biodiverse countries where new infrastructures accelerate deforestation and forest degradation (Laurance et al., 2017) contributing to global changes. On coastal areas, artificial coastal infrastructures are developed in response to land reclamation and sea level increase while their impact on wetlands and aquatic ecosystems is poorly understood (Choi et al., 2018). Speaking of concepts such as "biodiversity-friendly designs" or "urban green infrastructure" or "Working with nature" (PIANC), research must be continued to set up solid bio-indicators of ecological status and accountable metrics to indicate fragmentation, connectivity, and isolation of populations at different scales. In this matter, bio-indicators at the scale of community or ecosystem are generally more accurate than focusing on selected populations of rare or endangered species.

[xvi] An overlook of the 95 mega projects selected under the current H 2020 program by the European Union shows that none of them, though, has targeted urban related issues as a designated focus area.

[xvii] Tomorrow, the focus on large scale research infrastructures could also include space.

[xviii] Recent literature on sustainable finance, impact finance, responsible finance, finance and the SDGs, climate finance and infrastructures, etc. account for massive estimates, that is of global investment needs to achieve the Agenda 2030 of US$ 5 to 7 trillion per year with a gap of about US$ 2,5 trillion per year, and over one-third of it for Africa alone.

[xix] So far, a very limited number of institutions have managed to launch and to sustain advanced research programs connecting urban and regional development to environment and climate change through actual evidence and data collection based upon physical research facilities and large scale research infrastructures. The example of the transformative role of the Trans Siberian Scientific Way developed by the national research Tomsk State University could serve as a benchmark for such initiatives. It connects a mega-profile ranging from Central Asia to the Arctic Circle and a circumpolar network of research bases.