SUSTAINABILITY SCIENCE

UNDERSTAND, CO-CONSTRUCT, TRANSFORM
Volume 3

Collective thinking coordinated
by Olivier Dangles, Marie-Lise Sabrié and Claire Fréour

IRD Editions

SUSTAINABILITY SCIENCE

UNDERSTAND, CO-CONSTRUCT, TRANSFORM

Volume 3

Peer review board

Valérie Verdier, IRD Chairperson and Chief Executive Officer
Gilles Pecassou, Deputy Executive Director
Isabelle Benoist, General Secretary
Philippe Charvis, Deputy Director for Science
Marie-Lise Sabrié, Director of the Scientific and Technological Culture Mission
Claire Fréour, Sustainability Science Mission Director

SUSTAINABILITY SCIENCE

UNDERSTAND, CO-CONSTRUCT, TRANSFORM

Volume 3

Collective thinking coordinated
by Olivier Dangles, Marie-Lise Sabrié and Claire Fréour

IRD Éditions

French National Research Institute for Sustainable Development
Marseille, 2024

Editorial coordinator: Corinne Lavagne
Editorial preparation: Jasmine Portal-Cabanel
Cover, design and layout: Charlotte Devanz

Cover photo: Rock painting, Cueva de las Manos, Argentina.
© IRD/O. Dangles – F. Nowicki/*Une Autre Terre*

Photo p. 14: Preparing tubes for saliva samples, Gabon
© IRD/P. Becquart

Photo p. 40: Health centre in hot conditions, Senegal
© IRD/A. Makosi, Mopga project

Photo p. 70: Launching a drone on Changri-Nup, Everest, Nepal.
© IRD-CNRS/S. Vergoz, Preshine expedition

Photo p. 92: Participatory exercise on the theme of erosion, Indonesia
© IRD/Rights reserved

Photo p. 106: Fabrication of a terra cotta jar, craft village, Vietnam
© IRD/J.-M. Borée

Photo p. 128: Child's drawing, Madagascar
© IRD/S. M. Carrière

Published under Creative Commons license CC-by-NC-ND 4.0, which may be accessed at the following address: https://creativecommons.org/licenses/by-nc-nd/4.0/deed.fr
This license authorizes distribution of the original work, provided that the authors and publishers are mentioned and a link is included to the CC By-NC-ND 4.0 license. The publication must not be modified and must be distributed in its entirety. No commercial use is permitted.

© IRD, 2024

ISBN PDF: 978-2-7099-3041-3

CONTENTS

10 **Preface**
Valérie Verdier

12 **Introduction**
Olivier Dangles, Marie-Lise Sabrié & Claire Fréour

UNDERSTAND

16 **The science of implementation: from effective innovations to sustainable interventions**
Joseph Larmarange

20 **Human transport systems and sustainability**
Laetitia Gauvin

24 **The food-energy-water nexus for small islands**
Romain Authier, Benjamin Pillot, Guillaume Guimbretière, Pablo Corral-Broto & Carmen Gervet

28 **A paradigm shift in agricultural research to tackle climate change**
Heribert Hirt, Ndjido Ardo Kane & Laurent Laplaze

32 **Geodiversity, geofunctionality and land planning: an interdisciplinary perspective on non-organic resources**
Ottone Scammacca

36 **An obstacle to SDG 11 "Sustainable Cities and Communities": what makes a "slum"?**
Valérie Clerc

42 **An interdisciplinary approach to studying antimicrobial resistance**
Patricia Licznar-Fajardo & Jean-Louis Perrin

46 **Cognition at the heart of sustainability**
Guillaume Dezecache

50 **Global health challenges and solutions: what can sustainability science bring to the table?**
Andres Garchitorena

54 **The concept of the "sustainable city" in the Global South and the spectre of decolonisation**
Risa Permanadeli, Irene Valitutto, Martin Aweh, Innoussa Moumouni & Marie-Claude Ngando

58 **What can genetics bring to the concept of ecological sustainability?**
Romain Guyot, Rommel Montufar & Cédric Mariac

62 **Women in debt: the invisible cost of sustainability**
Isabelle Guérin

66 **Protecting marine food systems against the decline of coral reefs**
Eva Maire

CO-CONSTRUCT

72 **Intensifying the ecological functions of soils for a more sustainable agriculture: acting with actors**
Éric Blanchart & Jean Trap

76 **Equitable research partnerships: putting theory into practice**
Alice Chadwick El-Ali & Maggy Heintz

80 **Fishing in the Amazon: play first, negotiate later**
Marie-Paule Bonnet, Neriane N. da Hora, Kevin Chapuis, Christophe Le Page, Pierre Bommel, Joine Cariele, Gustavo Melo & Stéphanie Nasuti

84 **Participatory research and sustainability science**
Mina Kleiche-Dray & Maël Goumri

88 **The ambivalence of low carbon research with partners in the Global South**
Sylvie Fanchette, Nadège Letourneur & Emmanuel Pannier

94 **Analysing one's partnership style in co-constructed and co-directed projects**
Manuelle Philippe

98 **Joint field work, a catalyst to transdisciplinarity**
Sow Papa Gueye Sow, Antoine Baigue, Manon Balagi, Stéphanie Dos Santos, Ernest Haou, Jean-François Léon, Anastasia Mendy & Zohra Mhedhbi

102 **Developing disaster science as a means of reducing risks**
Julien Rebotier, Pascale Metzger, Jean-Mathieu Nocquet, Pablo Samaniego & Laurence Audin

TRANSFORM

108 **The digital transformation of African universities: opportunities and challenges for the SDGs**
Maïssa Mbaye, Gaoussou Camara & Hélène Kirchner

112 **How can we amplify and promote the impact of scientific research on society?**
Thomas Delahais & Agathe Devaux-Spatarakis

116 **Towards a didactics of sustainability**
Jean-Marc Lange

120 **Knowledge brokering: rising to the challenges of sustainability science**
Valéry Ridde & Tony Zitty

124 **Sustainability science in Horizon Europe collaborative projects**
Alice Comte, Stéphanie Juban, Laura Leblanc & Colin Volle

130 **Transformative territorial science: the example of the "Zones Atelier" network**
Olivier Ragueneau & Vanessa Lea

134 **In defence of artistic ecologies**
Nathalie Blanc

138 **Evaluating the sustainability of agricultural systems: The example of the Idea$_4$ method**
Frédéric Zahm, Sydney Girard, David Carayon, Bernard Del'homme, Inês Rodrigues, Adeline Alonso Ugaglia, Mohamed Gafsi, Clément Gestin, Pierre Gasselin, Chantal Loyce, Vincent Manneville & Barbara Redlingshöfer

142 *Outcome Trajectory Evaluation* –
Analysing the impact of research on policy
Boru Douthwaite

146 The Sustainable Development Goals
in the IRD's scientific publications
Laurent Guillou

PREFACE

Valérie Verdier
Chairperson and Chief Executive Officer
French National Research Institute for Sustainable Development

Since the beginning of my term as Chair and CEO in 2020, the IRD has been committed to thoroughly exploring sustainability science, adopting a unifying, collective approach to our research topics and activities. In partnership with many academic communities and research institutions in countries in the Global South, including France's overseas territories, we have put sustainability science at the heart of our scientific policy. This strategic vision and commitment enable the IRD and its partners to continue producing essential knowledge which will help to further our understanding of the complex challenges involved in ensuring the Earth is a liveable place in the Anthropocene era, co-constructing solutions for a sustainable, desirable future.

Integrating sustainability science into our work has permitted us, in the space of a few years, to better align our research with the 2030 Agenda for sustainable development, and also to think even further ahead. We have strengthened our science diplomacy efforts and developed a reflexive approach to our professional practices (carbon footprint, equitable partnerships, science with and for society). This philosophical framework is essential to maximising the impact of our research, co-constructed with local people in all of our partner countries and territories. These objectives are now written into our 2021-2025 Contract of Objectives, Means and Performance (COMP), drafted in collaboration with our two supervising ministries.

Sustainability science can take any number of practical forms, something reflected in the work of our Knowledge Communities (Cosav), interdisciplinary and cross-sectoral platforms for collective intelligence founded in 2021. This collective dynamic has had a transformative effect on the way we work within the Institute and across the IRD universe, greatly contributing to the success of our missions and our efforts to hit the targets set out in the COMP and the recently updated strategic plan (POS). It is binding not only upon the IRD teams, but also our international partners.

In 2024, as our Institute celebrates 80 years of discoveries, innovations and scientific advances, it gives me great pleasure to introduce this third instalment in our *Sustainability Science* series. This volume brings together 32 articles by more than 70 authors, illustrating the breadth and the dynamism of our collective endeavours. The range of topics addressed herein is testament to the continuous evolution of our conceptual and methodological frameworks, and the extent to which sustainability science is now firmly rooted within our community.

This third tome, structured around the three pillars of "Understand," "Co-construct" and "Transform," demonstrates the depth and diversity of our projects. These admirably varied contributions come from young scientists and doctoral students, research support staff, researchers, and even directors of international joint laboratories, evidence that sustainability science is woven into the fabric of everything our Institute does, providing an invaluable intercultural perspective. The articles collected in this volume constitute a vital source of information for anybody keen to better understand the stakes of sustainability science, enriched by concrete examples and first-hand experience.

I would like to express my sincere gratitude to all of the authors and editors for their precious contributions to this collection. Together, we continue to strive for a vision of research which is rich in meaning, in solutions and in transformative capacities for societies which are more sustainable, more respectful of life and more protective of our planet.

INTRODUCTION

Olivier Dangles, Marie-Lise Sabrié & Claire Fréour
IRD, Science Division

When the first "Sustainability Science Files" were published, more than three years ago now, a certain section of the French development research community regarded this "new" science with a degree of scepticism, or even outright suspicion. Was this just a "buzz word" being used by IRD management to dress up their new scientific policy, or did it herald a genuine paradigm shift urging researchers to find new solutions to the complex problems of today's world?

But the real question lies elsewhere. This collective reflection on themes of sustainability science is by no means an attempt to impose the IRD's scientific policy from the "top down", nor to prove that a transformative change is afoot in development research through sheer volume of words and number of authors. The motivation behind this collection is in fact to encourage each and every one of us to think more deeply about the concept of sustainability, a term which has bandied about since the 1970s, to the extent that it has become blunted through overuse. A resolutely polysemic term, it is impossible to offer a concise definition of "sustainability." We thus felt that it was important that a large and diverse selection of actors with direct experience of the complex challenges of sustainable development - researchers, engineers, advisers, project leaders, consultants, financial partners, facilitators, artists and diplomats from all over the world - should be given the opportunity to share their ideas, and that their reflections and suggestions should be collected in a work designed to inspire and to incite discussion.

The very first article of the first volume of *Sustainability Science* employed the metaphor of a bridge to describe sustainability science, connecting the academic world to other societal stakeholders;[1] and yet, just a few pages later, this paradigm was deconstructed by

1 • See Dangles O., Fréour C., 2022 – ' Sustainability science: finding sustainable solutions within the planetary boundaries' In: *Sustainability Science*, Marseille, IRD Editions: 16-19.

Julien Blanco and Clémence Moreau.[2] The two sociologists proposed replacing this metaphor with the triptych "understand, co-construct, transform," employing verbs rather than nouns to highlight the dynamic, entrepreneurial dimensions of sustainability, reminding us that it is a process rather than an end in itself. Indeed, by virtue of its commitment to co-construction, sustainability science succeeds in reconciling two discrete spheres - knowledge (understand) and action (transform) - for the purpose of putting theoretical and applied innovations to work in the pursuit of a fairer, more sustainable world.

Over the course of three years and 105 articles, no fewer than 252 authors from 70 institutions in over 30 countries have contributing to constructing, deconstructing and reconstructing an audacious, experiential vision of sustainability. In this third volume, we welcome new ideas and perspectives from the worlds of the arts, psychology, education science and knowledge brokering, enriching our collective reflection and underscoring the increasingly urgent need to align the production of scientific knowledge more closely with economic, ecological and social realities. This responsibility is all the more serious at a time when, as noted in a recent open letter signed by 260 researchers "misgivings about political power are increasingly taking root in our scientific community."[3] Faced with these challenges, we need to overcome the systemic difficulties which are hampering dialogue between the scientific and political spheres, as well as the social, economic and cultural spheres. We need to unite them all, and turn talk into action. That is surely the next task we must tackle, as we strive to co-construct a vision of sustainability which will enable us to imagine and shape the future of humanity in a world which is both ecologically secure and socially just.

---

2 • See Blanco J., Moreau C., 2022 – 'Understand, co-construct, transform: a triptych in need of social sciences?' In: *Sustainability Science*, Marseille, IRD Editions: 20-23.

3 • https://www.lemonde.fr/climat/article/2024/04/18/climat-une-defiance-grandissante-s-installe-dans-notre-communaute-scientifique-vis-a-vis-du-pouvoir-politique_6228470_1652612.html

UNDERSTAND

Understanding how to safeguard the well-being of current and future generations within planetary boundaries is at the heart of sustainability science. There is a growing demand for integrated knowledge about the Earth, social systems and their interfaces. This calls for new conceptual and methodological approaches.

The science of implementation: from effective innovations to sustainable interventions

Joseph Larmarange,
IRD, UMR Ceped, Paris, France

Background

Implementation science is concerned with the ways in which interventions based upon solid data are put into practice in real environments. In the field of healthcare, translational research (or transfer studies) exists at the intersection of fundamental research, concerned with understanding the mechanisms which underpin medical pathologies, and clinical research, which seeks to evaluate the efficacy and tolerance of new treatments or care strategies. Nevertheless, although the development of biomedical innovations is an essential element of the solution to health problems, these innovations alone are often not sufficient to have a real and lasting impact on epidemics. Implementation science, usually focused on the uptake of innovation, must thus seek to engage more with subsequent challenges associated with upscaling and securing interventions for the long term. In doing so, it can draw upon some of the key concepts of sustainability science: interdisciplinarity, intersectionality, holistic perspectives and local and global scales.

Contact
joseph.larmarange@ird.fr

Further reading
http://www.equitesante.org/wp-content/uploads/2017/04/mst-308579-la_mise_en_uvre_des_interventions_de_sante_publique_en_afrique_un_theme_strategique_neglige-WPe@uH8AAQEAAFNxq8AAAAAA-a.pdf

Obstacles to the transferral of innovation: the example of HIV in Africa

In the 1980s, a vast amount of research into the replication methods of HIV led to the development of new treatments. The arrival of antiretroviral treatments in 1996 constituted a genuine therapeutic revolution. Nevertheless, it was not until 2004 that the first programmes providing free access to antiretroviral drugs were launched in Africa, thanks to innovations in financing mechanisms (the establishment of the Global Fund to end AIDS in 2002 and the American PEPFAR programme - the President's Emergency Plan for Aids Relief - in 2003), drug production (particularly generic drugs) and improvements to healthcare systems. The number of people in the world living with HIV and receiving treatment thus increased from around 100,000 in 2003 to almost 19.5 million by 2020, and over the same time the number of recorded AIDS deaths decreased massively. This increased access to care also required certain innovations in terms of diagnostic tools. Rapid tests capable of detecting HIV within 30 minutes were developed in the 1990s, but here again it took many years for such testing services to reach low and middle-income countries. One major innovation has been the development of so-called "community" testing, as recommended by the World Health Organization since 2013, with testing delegated to non-medical partners trained in the necessary techniques. More recently, the advent of pre-exposure prophylaxis (PrEP), involving drugs which prevent HIV-negative persons from contracting the virus, has radically changed the biomedical prevention of HIV. PrEP is highly effective, on the condition that it is accessible and that users take it regularly. The Princesse project, co-coordinated by the IRD and focusing on female sex workers in Ivory Coast, has shown that the efficacy of PrEP is hindered by the living conditions of these women. PrEP medication must be taken orally every day and supervised by means of quarterly check-ups, something which is not particularly compatible with the highly mobile lives of these sex workers, and the time they are willing or able to devote to their health. The benefits of the treatment are not immediately visible, and thus do not compensate for the very real constraints of the follow-up work.

Interdisciplinarity and intersectionality

Given the complexity of the mechanisms at work in the production of healthcare inequalities, particularly in situations involving prostitution, it is crucial to diversify our investigative methods and combine multiple disciplinary perspectives on the same subject, establishing a dialogue between social sciences, health sciences and biological sciences, but also, both upstream and downstream, between local and international decision-makers, operators and, above all, beneficiaries themselves. Involving these different stakeholders allows us to mobilise and compare scientific knowledge, experiential knowledge and expertise from the field, and to better identify measures for experimentation. The Princesse project was co-constructed by means of a series of workshops involving various community NGOs and

the national anti-AIDS programme. Implementation in partnership with the NGO Aprosam, and maintaining a constant open dialogue with the medical team and peer-educators (community members trained in support provision), made it possible to more effectively identify operational and logistical challenges. Better appropriation of the research results by the population directly affected, by civil society and by political decision-makers (including the national anti-AIDS programme, in the case of the Princesse project) is a key component of lobbying efforts. Similarly, knowledge transfer should involve more than simply presenting research results; we need to think more comprehensively about the processes and activities most conducive to sharing and disseminating the knowledge produced by research.

Mobile sexual health clinic in a red light district, ANRS Princesse project, San Pedro region, Ivory Coast.

A holistic vision of health

The WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." This definition reminds us that health is not merely a clinical affair, inviting us to take full consideration of the other dimensions which make up our lives, including the social dimension. The silo organisation of care provision, with funding earmarked for specific conditions, has been the subject of regular criticism for decades. When it comes to health interventions, where it is impossible to tackle all health needs in a single operation, it is important to identify opportunities for pooling care resources and achieving economies of scale. It is, for example, entirely possible to plan actions from a population perspective rather than the perspective of a specific pathology or department. Multi-pathology approaches provide opportunities to get people thinking about health issues which may not be top of their list of priorities. The Princesse project demonstrates that a paradigm shift is possible. While the initial brief was to develop a PrEP programme, with broader sexual health services as a recommended adjunct, the intervention we ultimately developed in partnership with Aprosam encompasses a range of sexual health services, including PrEP, while remaining open to HIV-positive women, those who do not wish to take PrEP, and those suffering from Hepatitis B. Integrated approaches make it possible to provide a better quality of care and, in return, to maintain the motivation levels of medical personnel and community agents, which is essential to the sustainability of the project.

Local appropriation of global challenges

Global health challenges transcend national borders, and require collective action by the international community. As such, it is essential to consider how the lessons learned from local experiments can feed into the drafting of international recommendations. But it is every bit as important to re-examine policies and programmes with reference to the local context specific to each intervention. It is not possible to develop effective innovations without ensuring that, at the local level, interventions take full account of the structural and social barriers which people face. The somewhat disappointing results of the Princesse project stand in stark contrast with the enthusiasm for PrEP shown by many development agencies. This is by no means a miracle solution. What we need now are new tools, tools which are easier to use and more accessible. The forthcoming arrival of long-lasting treatment solutions could be a major step forward, as long as the follow-up process is revised and simplified.

KEY POINTS

Issues of implementation and upscaling are not simply operational problems. Developing effective tools is not enough; they also need to be deployed correctly, and tailored to the realities of the field in order to be effective. This requires a clear understanding of how interventions can accommodate the constraints faced by beneficiaries, as well as the structural, organisational, economic and political constraints inherent to healthcare systems. In order to secure the long term future of health interventions, implementation science needs to become even more interdisciplinary and intersectional, with the active involvement of decision-makers, actors in the field and the beneficiaries themselves.

Human transport systems and sustainability

Laetitia Gauvin,
IRD, UMR Prodig, Campus Condorcet, Aubervilliers, France

Background

The UN estimates that the world's urban population will grow by 2.5 billion by 2050, and almost 90 % of this increase is expected to occur in Asia and Africa. In the face of this rapid urbanisation, we need to rethink our urban transport systems. Population growth is driving growing demand for public transport. Moreover, the rise of average salaries in low income countries led to a more than 60% increase in the rate of motor vehicle ownership between 2005 and 2015 in Latin America and Asia. Changing transport habits and needs as a result of urbanisation are already posing major sustainability challenges. In this article, we look at the direct and indirect impacts of transport on various Sustainable Development Goals, identifying potential avenues for further research.

Contact
laetitia.gauvin@ird.fr

Further reading

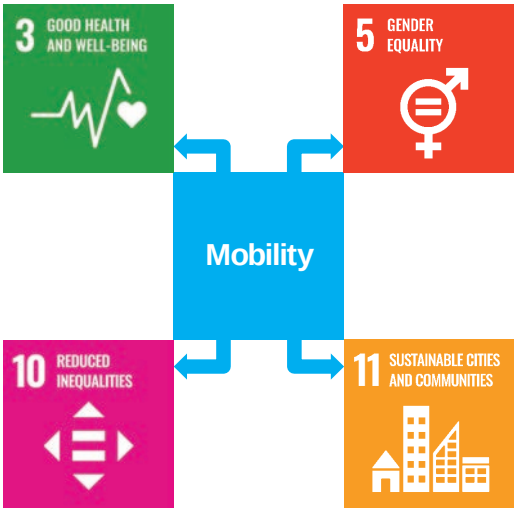
Turner P., Ciambra A., 2019 – *Mobility and the SDGs: A safe, affordable, accessible and sustainable transport system for all*, Gold Policy Series.

Transport and sustainable cities

Target 11.2 of the UN's Sustainable Development Goals calls for "access to safe, affordable, accessible and sustainable transport systems for all, improving road safety." And yet, the number of fatal road accidents continues to increase in many countries in Africa and South-East Asia, to such an extent that road accidents are now the leading cause of youth mortality in Africa. By modelling the connections between traffic flow data, urban transport infrastructure and accident number, it is possible to identify potential dangers and high-risk zones. Analysing and modelling transport flows is also key to understanding the factors which influence individual transport choices, and as such may provide clues as to how we can attenuate the negative environmental impact (Target 11.6) of day-to-day urban transport.

Transport and inequalities

In some cases, urbanisation in the Global South has gone hand-in-hand with an increase in inequality and social exclusion. Although urbanisation may open up new opportunities for the most vulnerable segments of the population, those opportunities may just as well prove to be inaccessible. Fair access to transport plays an essential role in reducing social inequality, as it also has a decisive influence on access to healthcare, education, amenities and employment. Evaluating disparities in accessibility with reference to gender and socioeconomic status, identifying those groups with the lowest level of service, is therefore a crucial step in the drive to provide equal opportunities. Segregation, which can exacerbate inequalities, is often studied in a static manner by looking at the geographical distribution of different groups in the population, but we can also adopt a more dynamic approach by analysing individual transport habits. As has been noted in some Brazilian cities, the distribution of the population in terms of the urban areas they visit and the different forms of transport they use may have the effect of reproducing segregation patterns already observable in the residential and professional spheres, thus exacerbating existing socioeconomic inequalities.



Direct and indirect impacts of transport on several SDGs.

Transport and health

The Covid-19 pandemic illustrated the extent to which health and transport are interconnected. In the early days of the pandemic, transport restrictions were one of the few methods available to help limit the spread of the virus. Mobility plays a key role in the replication dynamics of many pathogens. Measuring key mobility indicators is thus of great importance to epidemiologists. Transport habits also play a decisive role in the development of certain chronic illnesses. Promoting active forms of transport for everyday journeys, including cycling and walking, can help to tackle obesity and heart disease. Access to green spaces and the option of living in a city which promotes environmentally friendly modes of transport can also have a positive impact on people's health.

New perspectives for the study of transportation

Digital data - such as those stored on our mobile phones - could provide an invaluable source of information to complement the data derived from surveys, allowing us to study transport habits with a very high degree of temporal and spatial resolution. Mobile phone ownership continues to grow in low-income nations, raising the prospect of studying different transport systems with the help of tracking data. Furthermore, the availability of open data collated by volunteer-led initiatives such as OpenStreetMap makes it possible to map the urban transport infrastructure of cities in developed nations and a certain number of cities in middle-income nations such as Medellín, Colombia and Buenos Aires, Argentina. Open data about public transport can also help us to quantify disparities in accessibility. Effectively utilising these data flows often requires the use of sophisticated tools incorporating artificial intelligence. For example, unsupervised machine learning tools can be used to identify the reasons for individual journeys based solely on the GPS coordinates provided by mobile phones. The increasingly rapid development of AI methods for processing data on a vast scale, combined with growing rates of phone ownership among even the poorest segments of society in low-income countries, can help us to gain a better understanding of the multiple facets of urban transport systems in these countries. Nevertheless, as of yet very few studies have made use of these emerging data sources to probe transport disparities between lower and middle-income groups, or even gender and socioeconomic inequalities in urban mobility. Exactly how useful these digital data sources may be to researchers studying these inequalities remains to be seen. Moreover, since these data are collective passively from consenting users, they may be biased and unrepresentative of the population as a whole. It will thus be necessary to develop tools to correct the data. These caveats notwithstanding, using new data sources to study transport systems could open up new avenues for progress on the SDGs.

KEY POINTS

Technological advances can help us to better understand everyday mobility behaviours, in spite of the challenges involved in analysing vast, multidimensional datasets and getting round their blind spots. Properly evaluating disparities in mobility is an important step towards achieving inclusive mobility in line with SDG 10 (reducing inequality). Tackling urban transport disparities would also be a boost toSDG 5, ensuring that men and women have equal opportunities in matters of mobility. Furthermore, mapping disparities in mobility would be a major contribution toward SDG 11, making our cities safer, more inclusive, more resilient and more sustainable. The benefits of sustainable mobility are considerable, not least in terms of reducing emissions, improving public health and working to deliver social and economic justice.

The food-energy-water nexus for small islands

Romain Authier [1], Benjamin Pillot [1], Guillaume Guimbretière [2], Pablo Corral-Broto [1] and Carmen Gervet [1][1]

Background

Like microcosms of the Earth itself - a planet capable of hosting life, an oasis amid the vast, hostile emptiness of space - small islands are pockets of life with limited resources, surrounded by vast expanses of salt water. These territories, often small in relation to their growing populations, are particularly vulnerable to economic crises and natural disasters. They are also highly dependent upon imports, which undermines the sustainability of their social and environmental trajectories, hence the urgent need to develop their autonomy with regard to the fundamental resources of water, food and energy. The interconnectedness of and competition for access to these resources are exacerbated for small islands, and as such a systemic approach is needed to properly engage with the integrated dynamics of the FEW nexus (food/energy/water).

Contact
romain.authier@umontpellier.fr

Further reading

Direction de l'Alimentation, de l'Agriculture et de la Forêt (DAAF) – *La protection du foncier agricole à La Réunion.* https://www.reunion.gouv.fr/IMG/pdf/Protection-foncier-La-Reunion.pdf

Modelling the complexity of the food-energy-water nexus

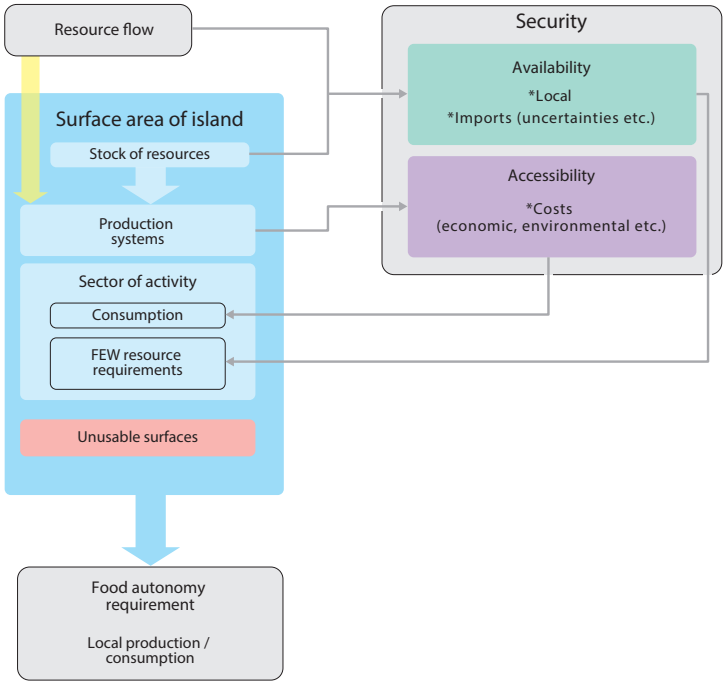
One way of studying the food autonomy of small islands is to focus on the degree of security achieved for the interconnected essential resources of food, energy and water (FEW), bearing in mind the spatial restrictions engendered by geographical isolation. To do this, we need to find an effective method of modelling FEW dynamics, devoting special attention to the division of land resources among different activities. Each component of the FEW nexus can be quantified in terms of its impact on land usage dynamics (impact of agricultural development, energy production projects and water usage). The total surface area of available land on the island can thus be regarded as a limiting resource, inhibiting the development of the production systems associated with the three other interconnected resources. In the context of the FEW nexus, urbanisation is the principal spatio-temporal variable determining the equilibrium between water, energy and food, inducing changes in patterns of land usage. Much of the increase in urbanisation has been driven by residential expansion as a result of population growth; this leads to an expansion of urbanised areas, but also places greater demand on water, energy and food resources, thus fostering the development of local production systems which take up large amounts of land, with a view to securing the supply of these interconnected resources.

The preferred strategy for modelling the FEW nexus is to focus on the issue of food autonomy. The food system can be broken down into successive phases, from production to waste management via processing, distribution and consumption. The model is designed to analyse the interconnections between the different dimensions of the nexus, breaking down the food system into its component sectors (agriculture, residential/tertiary, transport and industry). Each sector can thus be evaluated in terms of its resource consumption, with demands which evolve dynamically in response to urban development. Food autonomy, as an objective, is about securing key resources within the food system, guaranteeing the reliability and viability of their supply and satisfying the demand for food, water and energy resources emanating from all of the sectors of activity which collectively constitute the food system. To this end, security indicators are constructed for each resource, with reference to two key criteria: availability and accessibility. The model delivers an analysis of the sustainability of the food system based on these security indicators for each component of the FEW nexus, incorporating their reciprocal influences on patterns of land usage.

Identifying thresholds and limits, obstacles on the path to food autonomy

Modelling the food system using the FEW nexus allows us to study the complex interactions between its component parts in multiple scenarios: for energy, some scenarios involve low-power energy production projects (solar panels etc.); agricultural development has various consequences for local people; projects

1 • [1] UMR Espace-Dev, Montpellier, France; [2] UMR Laboratoire de l'atmosphère et des cyclones, La Réunion, France.



Applying the FEW nexus approach to food autonomy for small islands.

to increase the use of subterranean water resources also come at a price. This leads to increased competition for land usage. With regard to the choice of scenarios, it was not the purpose of our study to identify the most desirable solution. We believe that modelling, however detailed it may be, is never perfect. There are any number of constraints which we did not take into account, making these scenarios - which may seem achievable in the context of the model - operationally uncertain. Nonetheless, they do enable us to offer robust estimates of critical thresholds and hard maximum limits for FEW resource usage and land occupation across the island as a whole. In this respect, it is a useful decision-making tool. It succeeds in demonstrating the existence of a food autonomy threshold for a given population, a limit beyond which the security of food, energy and water resources and the availability of land can no longer be guaranteed.

Applying this approach to Reunion Island

We have used the FEW nexus to assess the food autonomy of Reunion Island. With a surface area of 2,512 km² and a population of

861,210 habitants (in 2019), Reunion is particularly vulnerable to natural disasters as well as land use pressures linked to urban sprawl. Available land is severely limited by the size of the island's national parks (42% of total territory), and Reunion remains highly dependent on imported foodstuffs (especially rice, a staple of Creole cuisine). As such, by virtue of its high population density and small usable surface area, Reunion can be regarded as a small island. This makes it a useful "laboratory" in which to study the stakes of the FEW nexus for small islands, with particular reference to food autonomy. In recent years, a section of the population has begun to express concern at the island's lack of autonomy. The isolation induced by the Covid-19 pandemic accelerated this phenomenon, and saw the emergence of initiatives to reintroduce rice plantations using local varieties. However, the results generated by our model suggest that it will be difficult to secure FEW resources and achieve full food autonomy for the island using these varieties, since their yields are too low (3.3 tonnes/hectare) and they require far too much irrigation (3,000 m^3 of water/hectare/cycle). The action with the potential to deliver the biggest impact would be to encourage people to change their diets to include more high value added foodstuffs such as fruits and vegetables (including legumes, leaf vegetables and tubers), a diet already adopted by part of the population.

KEY POINTS

Making life on small islands sustainable requires a systemic approach, integrating questions of FEW resources with land resource management. To this end, our modelling technique focuses on competition between different forms of land use, and the compromises required to achieve food autonomy while securing the supply and consumption of FEW resources.

A paradigm shift in agricultural research to tackle climate change

Heribert Hirt,
Kaust, Thuwal, Saudi Arabia
Ndjido Ardo Kane,
Isra, Ceraas, Thiès, Senegal
Laurent Laplaze,
IRD, UMR Diade, Montpellier, France

Background

Greenhouse gas (GHG) emissions from human activities are the root cause of a global climate crisis, and solutions must now be found to attenuate the negative consequences for our planet. Agriculture accounts for around 25% of total GHG emissions. Carbon capture by means of photosynthesis could play a central role in reducing atmospheric CO_2 emissions. Solutions involving the core trifecta of soils, plants and microorganisms can help us to actively combat the nefarious effects of climate change. Such solutions require strategies which integrate knowledge ideas from multiple disciplines and sectors.

Contact
heribert.hirt@kaust.edu.sa
ndjido.kane@isra.sn
laurent.laplaze@ird.fr

Further reading

Cissé A. *et al.*, 2023 – Agrobiodiversité et transition agroécologique : Regards croisés de chercheurs et paysans. *Biodiversité des écosystèmes intertropicaux : connaissance, gestion durable et valorisation*.
https://www.plant-act.org/
Hirt H. *et al.*, 2023 – PlantACT! How to tackle the climate crisis. *Trends in Plant Science*, 28: 537-543.

Reducing greenhouse gas emissions, an essential priority

Over the past 150 years, it is estimated that the atmospheric concentration of CO_2 has increased from 280 ppm to 420 ppm as a result of human activities. 20-25% of anthropic GHG emissions can be attributed to agricultural activities. As well as CO_2, agriculture produces significant quantities of methane and nitrous oxide (N_2O), GHGs which are much more potent than CO_2 (>20 and 300 times, respectively) in terms of their warming potential. Although far more potent than CO_2, methane and N_2O also have far shorter life spans (12 and 114 years respectively, compared with anywhere between 300 and 1,000 years for CO_2). Reducing emissions of these two greenhouse gases would thus have an immediate impact on the climate.

What solutions are available to reduce the use of these three gases in agriculture?

A large portion of the CO_2 emissions generated by agriculture come from changes in land usage, and particularly from deforestation for the purposes of livestock farming (to produce fodder or clear land for grazing). Livestock and the fodder they consume are responsible for the equivalent of around 3 billion tonnes of CO_2 each year. In the short term, reducing our consumption of animal-based products is the most effective means of reducing the climate consequences of agriculture.

Methane is the second most important greenhouse gas, in terms of emissions. On top of the methane produced by livestock, aquatic rice production is responsible for 15 to 20% of anthropic methane emissions, due to the decomposition of organic matter in anaerobic conditions by methane-releasing bacteria. Alternative agronomic practices which reduce the duration of anaerobic phases, such as alternating irrigation or aerobic rice farming, can significantly reduce both methane emissions and water consumption. Nevertheless, they will also need to be optimised in order to prevent a decline in yields, and to offset the greater year-to-year variability of yields induced by greater competition from adventive plants (i.e. plants other than food crops), reduced water availability and the presence of pathogens such as nematodes.

Once it has been spread on the fields, a large proportion of nitrogen-based fertiliser is transformed into N_2O through microbial activity in the soil. These synthetic fertilisers, whose production requires large quantities of fossil energies, account for over 2% of GHG emissions. If agricultural practices do not change, demand for chemical nitrogen-based fertilisers will grow by 50% by 2050 if we are to feed the growing global population, with GHG emissions increasing accordingly. In the short term, the use of nitrogen-based fertilisers could be reduced immediately by optimising agronomic practices and providing farmers with pertinent advice. In the short to medium term, a transition to agricultural systems prioritising legumes and pulses, which naturally capture nitrogen from the atmosphere, is a key priority. In the long term, boosting the efficacy of nitrogen uptake and usage by cereal crops (less than 50% of nitrogen-based fertilisers are actually absorbed and used by crops) would allow for substantial increases in crop yields while limiting the use of these fertilisers.

Soils, plants and microorganisms: potential contributors to the attenuation of climate change

As the principal source of carbon and energy for microorganisms living in the soil, plants could be a central pillar of carbon-capture strategies. For example, some plants secrete oxalate from their roots, which is used by microbes in the soil (Hirt *et al.*, 2023). In return, these microorganisms modify the physical and chemical properties of the soil and play an important role in carbon capture by contributing (in a manner which may be positive or negative) to the formation of stocks of organic or inorganic carbon in the soils. The advantage of the latter is that it is more stable, and could thus form the basis of carbon capture strategies to combat global warming. In arid soils and soils rich in calcium and magnesium, we find many microorganisms producing calcium or magnesium carbonate, inorganic forms of carbon which remain stable for decades. These natural CO_2 storage systems could thus inform innovative carbon capture strategies in arid zones, without competing for land resources with agriculture in more fertile areas. Moreover, protecting and expanding forests are often touted as means of capturing atmospheric carbon and creating carbon sinks. The African Union's Great Green Wall (GGW) initiative - which aims to restore 100 million hectares of degraded landscapes by 2030, a band 15 km wide and 8,000 km long running across the southern Sahara from Dakar to Djibouti - is a concrete example of this type of strategy. Estimates suggest that this initiative could capture and store up to 250 million tonnes of CO_2.

A paradigm shift to transform agriculture

A paradigm shift is needed so that plant scientists are not left to work in isolation, seeking partial solutions to global problems. The PlantAct! Initiative, recently launched by a group of experts from all five continents with the aim of operating like a think tank and generating new ideas for attenuating the effects of climate change. The PlantAct! approach is focused on creating opportunities to share expertise between all stakeholders in agricultural production systems, as well as promoting programmes of interdisciplinary research. With more than 100 members across 31 countries, PlantAct! organises regular conferences around the world, inviting international experts to inform and inspire discussions on how best to adapt to climate change. The initiative is especially keen to promote solutions based on practical agronomic adjustments (varying plant varieties, modifying sowing dates, crop rotation based on the availability of water etc.) capable of limiting the impact of climate change on agricultural output (see for example Cissé *et al.*, 2022). Members feel strongly that, in the medium and long term, we need to develop new agricultural systems which are more resilient and better-suited to local conditions, potentially integrating indigenous knowledge and combining it with improved varietal selection. This evolution should enable diversification of agricultural production, with positive consequences for ecosystems, biodiversity and people. In order for agriculture to become more productive and more resilient, research

Screen shot of the PlantAct! website (www.plant-act.org).

must: 1) generate knowledge and innovations which serve to mitigate the negative impact of climate change on agricultural output and bring about positive, lasting change; 2) make the results of research scalable and accessible for users and beneficiaries; 3) increase general awareness of this research across society as a whole.

KEY POINTS

As we face up to climate change and its impact on our agricultural production systems, research must seek to identify integrated solutions based on the interactions between plants, soils and the environment. The soil/plant/microorganism complex should thus be placed at the heart of future strategies to capture and store more carbon in our food production systems, reducing GHG emissions in the process. A paradigm shift is needed to kick-start the transition towards a more sustainable agriculture, and to imagine new solutions for reducing man-made GHG emissions.

Geodiversity, geofunctionality and land planning: an interdisciplinary perspective on non-organic resources

Ottone Scammacca,
IRD, UMR Prodig, Aubervilliers, France

Background

First coined in 1993 and still largely overlooked by the general public, the concept of "geodiversity" is the material counterpart to biodiversity. The most widely used definition of the term refers to the natural variability of the Earth's geological, geomorphological, pedological and hydrological components, as well as their structures, combinations and contributions to landscape formation. Often neglected, these components can provide a multitude of ecosystem services, responding to various societal needs and requiring different approaches to land planning. Integrating geodiversity into our analysis of the interactions between human societies and natural environments can help us to better understand how sustainability fits into better territorial management. This requires a more comprehensive, interdisciplinary vision. This approach is especially important in the Global South and overseas territories such as French Guiana, where sustainable land use and conservation are beset with multiple challenges at the local, national and international levels.

Contact
ottone.scammacca@ird.fr

Further reading

Brilha J. *et al.*, 2018 – Geodiversity: An integrative review as a contribution to the sustainable management of the whole of nature. *Environmental Science & Policy*, 86: 19-28.

Scammacca O. *et al.*, 2022 – Geodiversity Assessment of French Guiana: Challenges and Implications for Sustainable Land Planning. *Geoheritage*, 14: 83.

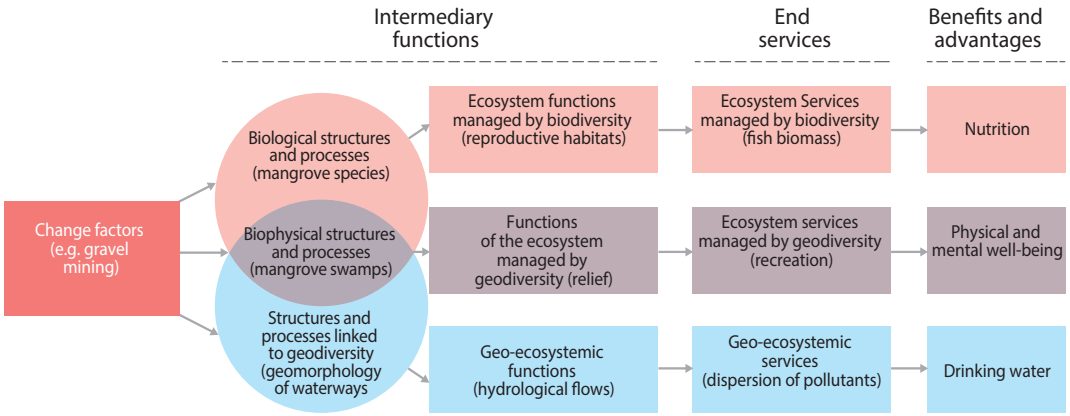
From georesources to geodiversity: valuing non-organic materials for more than their practical uses

Increasingly, geodiversity is being taken into consideration for land planning and geoconservation purposes, evaluating the frequency or abundance of physical entities (e.g. different types of rock and soil) within a given space, giving a measure of the degree of landscape heterogeneity. However, such evaluation cannot be the sole criterion informing territorial planning and geoconservation strategies. From a functional perspective, that part of nature which is not alive has traditionally been regarded as a source of mineral raw materials of use in day-to-day life (building materials, jewels etc.). But this extractivist vision overlooks the multiple roles that geodiversity plays in the socioecological functions of our territories (what we might call geofunctionality). Can zones with low "geodiversity" still be highly functional, and vice versa? It would be extremely reductive to regard extractive activities purely in terms of the geographically isolated industrial exploitation of specific objects; the concept of geodiversity - rather than "georesources" - allows us to expand the framing of the issue beyond the confines of the mining industry, encompassing all of the non-living components of our territories and their reciprocal interactions with the biosphere and the anthroposphere. Mining is only one way among many of profiting from geodiversity.

From geodiversity to geofunctionality: the connections between society and the non-living world

Geodiversity plays a key role in the supply of raw materials, but also in regulating the quality and quantity of the water supply. Geodiversity can regulate natural risks and erosion processes; it has a major influence on elemental nutrient cycles as well as pedological structures which serve multiple purposes (agriculture, urbanisation, forestry structures) and the habitats which underpin biodiversity. In fact, geodiversity is studied closely as a major predictive variable for biodiversity, as it can influence the likelihood of species cohabiting, or else create niches conducive to speciation. Last but not least, geodiversity comprises a significant cultural dimension which may be manifested in the form of geoconservation and its educational, scientific and historical values, or else in the emergence of recreational activities designed to promote and protect noteworthy geological sites on a national scale (e.g. French government decrees protecting specific geotopes), or at international level (e.g. the UNESCO Geopark label).

Geodiversity must therefore be understood as a multifunctional combination of entities collectively capable of providing multiple ecosystem services, as well as contributing to the construction of territorial identities. In this respect it has the capacity to act as an ecological, economic and sociocultural catalyst for territorial development, encapsulated in the natural and man-made landscape. At this scale, geodiversity interacts with the



Examples of ecosystem services connected to geodiversity.
Adapted from Fox *et al.*, 2020 – Geodiversity supports cultural ecosystem services: an assessment using social media. *Geoheritage*, 14 (1): 27.

anthroposphere through the multiple and sometimes competing uses of resources and spaces: the landscape can thus be regarded as a fundamental unit of sustainability, and the level at which Sustainable Development Goals (SDGs) must be delivered. As such, the scientific output of geoecology (also known as "landscape ecology") must be backed up with a raft of new interdisciplinary, or even transdisciplinary, concepts, theories, predictive models and methods, indicators and analytical frameworks, involving all territorial actors. Such a holistic vision would facilitate decision-making and diversification in the way we use natural spaces, better aligning land usage with functional potential. The diversification of services and uses associated with geodiversity could thus help us to prioritise well-aligned land management strategies and identify the best way to meet our needs while minimising their negative consequences.

Geodiversity as a gateway to sustainability science in the overseas territories: the example of French Guiana

The challenges of sustainability, evident in the difficulties affecting land and resource management, are particularly acute in France's overseas territories. By virtue of their history, these territories are well acquainted with rapid changes (e.g. in demographics, or land usage) and a general disconnect between the way resources are actually used and the potential positive impact they could have for the territory. In French Guiana, a major pilot territory for building and experimenting with these new approaches, geodiversity has historically been discussed almost exclusively from a mining perspective (gold mining, to be precise). And yet, geodiversity is about

more than gold and its uses go far beyond the mining industry. Understanding the pedological diversity of Guiana, for example, could strengthen agricultural development policies which, at time of writing, partially neglect this dimension. Using abiotic parameters to identify wetlands could also help us to attain a more detailed understanding of how they function, particularly with regard to the carbon cycle, risk management and efforts to support biodiversity. Guiana is also home to a very large number of remarkable geosites, constituting the only geo-heritage of its kind in France, and one which is culturally and economically undervalued. The scientific knowledge produced by geoecological approaches is "useful" and "operable" for territorial actors, allowing for more informed decision-making in matters of sustainable land management.

KEY POINTS

As political economist Karl Polanyi noted as far back as 1944, life would not be possible without the ground beneath our feet! Geodiversity provides a multitude of ecosystem services which are directly or indirectly beneficial to human societies. Depending on the needs identified, these services can take a vast array of forms, shaping land management projects which may have positive and/or negative consequences for geodiversity and its functionalities. Properly integrating this concept into sustainability science and public policy discussions will be essential to the emergence of inter- and transdisciplinary approaches and sustainable territorial development strategies, as well as achieving various SDGs including SDGs 3, 9, 12, 13 and 15. French Guiana is an invaluable pilot territory for the experimental development and operational deployment of such approaches.

An obstacle to SDG 11 "Sustainable Cities and Communities": what makes a "slum"?

Valérie Clerc,
IRD, UMR Cessma, Paris, France

Background

In 2023, around 1.1 billion people lived in "slums or equivalent circumstances", and the UN expects this figure to increase by 2 billion over the next thirty years. One of the Sustainable Development Goals (SDGs) announced in 2015 was to "make cities and human settlements inclusive, safe, resilient and sustainable," including access to decent housing for all and the redevelopment of what the UN now officially refers to as "slums and informal settlements." In 2023, the SDG progress update report found that efforts to deliver Goal 11 "Sustainable Cities and Communities" were behind target. The UN's warnings appear to have had little effect. In proportional terms, the number of city-dwellers living in informal settlements may have decreased, but rampant urbanisation means that in absolute terms the number has increased. In fact, that growth appears to have picked up pace in recent years… to the extent that we are able to quantify it! Because how should we assess this SDG? How exactly do we define a slum? Focusing on definitions may help us to better understand the difficulties inherent to achieving this goal.

Contact
valerie.clerc@ird.fr

Further reading
https://www.cessma.org/CLERC-Valerie

A definition associated with the Millennium Development Goals

Announced in the year 2000, the Millennium Development Goals set ambitious targets for improving living conditions for 100 million slum dwellers by 2020 (target 7d). In order to hit this quantified target, an expert group mandated by the UN offered an international definition of slums in 2002: "a slum is a contiguous settlement where the inhabitants are characterised as having inadequate housing and basic services. A slum is often not recognised and addressed by the public authorities as an integral or equal part of the city." The experts also identified five defining characteristics of slums: insecure residential status, inadequate access to safe water, inadequate access to sanitation and other infrastructure, poor structural quality of housing, and overcrowding. Any household suffering from one or more of these problems could be regarded as a "slum household." For example, adequate access to water was defined as the ability to access a sufficient quantity of water (20 litres per person and per day) at an affordable price (less than 10% of total household income) without extreme effort for the members of the household (less than one hour per day required to obtain sufficient water), particularly women and children. In the intervening decades, these characteristics have frequently been used to define slums in the academic literature, and also by the UN itself.

The diversity of "slums and informal settlements": renovated *mukhalafat* neighbourhoods in Damascus (Syria, photo 1: 2008 and Photo 4: 2009) *squatters'* settlements in Phnom Penh (Cambodia, photo 2: 2003) and *kyu kyaw* neighbourhood in Yangon (Myanmar, photo 3: 2017).

The international variation in the number of slum dwellers has been dependent on the definition of slums

It soon became clear that the census criteria would need to be modified in order to better align with the reality on the ground, and particularly the pragmatic requirements of counting. In 2008, "insecure residential status" received the qualifier "real or perceived," making it impossible to measure. It thus disappeared from the census criteria, and the other criteria were loosened too. Changes were made to the definitions of inadequate access to sanitation (increasing the number of households who could acceptably share a toilet), access to water (quantity was no longer taken into account) and overcrowding. As a result of these changes, the official number of slum dwellers dropped in 2009. Finally, in 2015, the SDGs dropped the quantitative targets altogether and reasserted the position - a leitmotif of UN proclamations since the first Habitat conference in 1976 - that the best way to make "slums and informal settlements" disappear is not to knock them down or evict their residents, but rather to redevelop them and improve living conditions.

Local categories in public policy aimed at disappearing parts of cities

There is a further layer of complexity thwarting international estimates: the UN does not count households directly, instead compiling the figures submitted by each country. But, like other types of settlement, the definition of a "slum" can vary from one country to the next, or even from one city to the next. From the *favelas* of Rio de Janeiro to the *colonias populares* of Mexico City, the *bastis* of Kolkata to the *mukhalafat* of Damascus, these areas have different names which reflect the diversity of conditions on the ground - from makeshift shelters made of straw or scavenged materials on illegally occupied land to ten-storey buildings made of reinforced concrete on land which is legally owned but does not have planning permission - making an international definition even harder to attain. Research suggests that, even now, local definitions are responsible for making some parts of cities "informal," or inferior to other parts. Indeed, deciding which neighbourhoods should receive special treatment (and why) is a matter of public policy. On an international scale, the only universal definition of "slums" or "informal settlements" is as a category created by and for the purposes of local urban policies, earmarked as neighbourhoods which need to disappear, either through demolition or else through radical transformation leading to integration (in the latter case, after renovation the neighbourhood should no longer - in theory - belong in the "slum" category). In reality, there is no shared characteristic which defines all "slums and informal settlements," simply a threat of eradication wielded by institutions, a threat which often serves to exacerbate their precarious existence, particularly in terms of land tenure.

The ontological challenges of organising the renovation work urged by the UN

The goal of erasing certain types of buildings from cities is a matter of public policy in terms of urban strategy, but also owes much to the

representations of cities prevalent in local decision-making processes. It might be the case that certain parts of cities are regarded by decision-makers as being insufficiently "urban" to endure, with particular characteristics which exclude them from being affiliated with the city (e.g. the building materials used, the width of the streets, the size of the homes, the value of the real estate etc.). Redeveloping districts which have been earmarked for eradication is often difficult to imagine. This is the main reason why the UN edict to improve these neighbourhoods is difficult to put into practice on the ground; those that have been successfully redeveloped are in the minority, and arriving at such decisions is often a long and rocky road for incoming governments: in fact it flies in the fact of existing definitions of the city.

KEY POINTS

For almost fifty years now, the UN's calls to renovate and rehabilitate "slums and informal neighbourhoods" have gone largely unheeded. This objective was reaffirmed in SDG 11 "Sustainable Cities and Communities," albeit to little effect: there are still over a million people living in such settlements, and that number continues to grow. Analysing the way we define such neighbourhoods casts light on the problem. If we discard the definition proposed by the UN, which vainly attempts to identify shared physical characteristics among a highly diverse array of settlements, and instead focus on the definitions of such neighbourhoods which inform public policy, i.e. definitions based on their intended fate - local urban planning policies generally regard "slums and informal settlements" as being destined to disappear - then it is not hard to see why SDG 11 is proving so difficult to implement. It is not easy for decision-makers to accept that these neighbourhoods are permanent entities in need of improvement, when they have always regarded them as problems to be eradicated.

An interdisciplinary approach to studying antimicrobial resistance

Patricia Licznar-Fajardo & Jean-Louis Perrin,
HSM, Université de Montpellier, IRD, CNRS, Montpellier, France

Background

With a population of 1.5 billion in 2023, estimated to rise to 2.5 billion in 2050, the African continent could be home to 40% of the world's population by the end of the 21st century. Furthermore, with more than half of the population now living in urban areas, Africa is the world's most rapidly urbanising continent. The rapid rate of population growth and urban development could represent an obstacle to the attainment of SDG 6, which "seeks to ensure safe drinking water and sanitation for all, focusing on the sustainable management of water resources." We have chosen to adopt an interdisciplinary approach combining hydrology and antimicrobial resistance in order to contribute to evaluations of the sustainability of a resource which is under great pressure on the periphery of Abidjan.

Contact
patricia.licznar-fajardo@umontpellier.fr

Further reading

https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)02724-0/fulltext
https://www.woah.org/app/uploads/2021/10/unsdcf-amr-guidance-en-final-approved.pdf
https://www.woah.org/fileadmin/Home/eng/Media_Center/docs/pdf/FAO_OIE_WHO_AMRfactsheet.pdf

Antimicrobial resistance: a pernicious obstacle to the SDGs

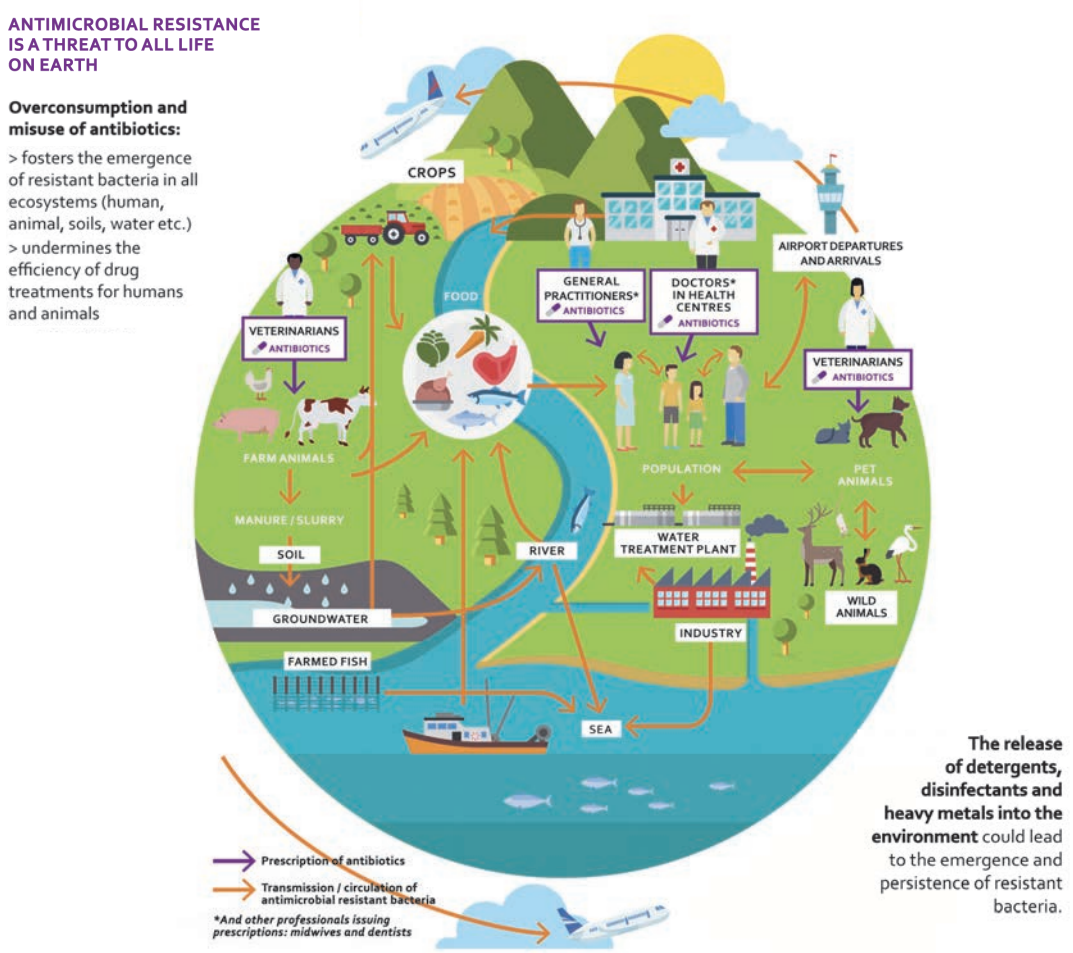
In the mid-20th century, the development of antibiotics revolutionised the treatment of infectious diseases. The golden age of antibiotics proved to be short-lived, as misuse and overconsumption rapidly exerted severe selective pressure on bacteria and led us to our current state of affairs: the development of widespread resistance (antimicrobial resistance) among pathogenic bacteria, compromising the efficacy of our therapeutic arsenal. In 2019, an estimated 1.3 million people all over the world died as a result of antimicrobial resistance. The emergence and dissemination of antibiotic-resistant pathogenic bacteria and the resistant genes they carry represent global threats which could hinder progress towards the targets of the Sustainable Development Goals unless urgent action is taken: SDG 3 "Good health and well-being" (and two of its targets specifically), SDG 6 "Clean water and sanitation" and SDG 12 "Responsible consumption and production." Like many of the major health challenges of the 21st century, the WHO believes that the widespread increase in antimicrobial resistance requires a "One Health" response. This is an intersectional, interdisciplinary problem which cannot be solved from a purely medical angle. Microbial resistance as a human health problem is increasingly closely linked to issues of animal health. For example, the French Ecoantibio project aims to reduce the use of antibiotics in the veterinary sector. Nonetheless, at time of writing, efforts to evaluate the role of environmental factors in the epidemiological cycle of antimicrobial resistance, and thus to monitor and study these environmental dynamics, remain inadequate. And yet, this knowledge would be of crucial importance to better understanding the role of environmental antimicrobial resistance in the emergence of resistant pathogenic bacteria and their impact on human health.

The place of water in a holistic approach to antimicrobial resistance

Antimicrobial resistance affects numerous ecosystems, and water plays a central role in the dissemination of resistances between microbial communities in different ecosystems. Aquatic ecosystems provide continuity between compartmentalised hydrological (surface water, underground water etc.), biotic (natural habitats for various organisms) and technological (waste water treatment, urban waste water, drinking water) milieus. As such, water is: 1) a matrix of interactions, the place where antimicrobial resistance emerges/disseminates via bacterial communities indigenous and external to the aquatic milieu; but also 2) a potential vector of antimicrobial resistance and of pathogenic bacteria in general, due to the regular daily contact between humans and water.

Water quality and ecological status in the Djibi river and Aghien lagoon

With a population of 5 million, the greater Abidjan area faces significant challenges when it comes to securing the drinking water supply. The Aghien lagoon, the only freshwater reservoir in the area, has been identified as a potential source of water for the city. Unfortunately,



The antimicrobial resistance cycle
(from https://antibioresistance.fr/grand-public).

the main tributary of this lagoon, the River Djibi, has its source in an area occupied by informal settlements where a large proportion of household waste water is discharged directly into the drainage system, or else into natural water courses without any form of treatment.

The Evidence project (Extreme rain, vulnerability and environmental risks: flooding and water contamination, 2018-2023) brought together Ivorian and French researchers from the Institut Pasteur in Ivory Coast, UMR HydroSciences Montpellier (IRD, Université de Montpellier,

CNRS, Institut Mines-Télécom) and the universities of Félix Houphouët Boigny and Nangui Abrogoua in Abidjan. Sampling and analysis of the waters of the Djibi were conducted in baseflow and overflow conditions. These readings enabled the research partners to jointly quantify the concentrations and flows of bacterial contaminants, nutrients and metallic trace elements, as well as their spatial and temporal variability. The results reveal that the dynamics of bacterial transfer mirror those of the contaminants present in particle form (in suspensions), and that the contaminants can be traced back to two key zones: the river bed (where particles accumulated between overflow periods) and urban areas (washed into the river from the streets and drainage channels during high water). In both baseflow and overflow conditions, significant quantities of pollutants are washed into the lagoon. In addition to pollutants responsible for eutrophication and numerous heavy metals associated with human activities, microbial contamination can also travel downstream into the lagoon, potentially posing a risk to human health. The territorial distribution of bacteria exhibiting worrying levels of resistance for human health has been objectively identified from the lab data. There are two scientific hypotheses which might explain the disparities of distribution recorded: a dilution effect thanks to the inflow of uncontaminated water and/or the dying off of resistant bacteria. Moreover, the inadequacy of waste water treatment infrastructure and the "unregulated" drug might also explain the presence of worrying strains of drug-resistant bacteria in the waters of urban and peri-urban rivers. Controlling these factors more effectively will be key to the fight against antimicrobial resistance. This study, based upon a One Health approach, is the first to describe the influence of run-off from a territory (drainage basin) on the presence of antimicrobially resistant bacteria at different levels, in baseflow and overflow conditions, in an urban and peri-urban aquatic milieu in Ivory Coast.

KEY POINTS

The capacity of water to act as a potential vector of pathogens towards humans is a crucial problem for many emerging countries, where lagoon waters may be used for drinking, cooking, cleaning and personal hygiene. This multidisciplinary study opens up new perspectives for original scientific projects bringing together all actors with an interest in the antimicrobial resistance cycle. Holistic approaches of this kind enable us to develop epidemiological research which remains fully attuned to environmental factors, demonstrating the potential of the One Health philosophy.

Cognition at the heart of sustainability

Guillaume Dezecache,
UMI Source, Université Paris-Saclay, UVSQ, IRD, France

Background

If the aim of sustainability science is to understand the dynamics of socioecological systems and to analyse their sustainability prospects, then a nuanced understanding of the psychology of the actors involved is utterly indispensable. In other words, we need to understand what motivates these actors, what encourages them and what holds them back. Much will depend on what they are capable of perceiving, learning and understanding. Far from being a proverbial *tabula rasa* ready to receive sensory experiences, our cognitive system has inherent limitations, constraints and blind spots. While the international sustainability science community has begun to engage with the "cognitive sciences", as of yet there has been relatively little discussion of these matters in the French-speaking world. In order to bridge this gap we must now train a new generation of students and researchers, in both the Global South and Global North, in the cognitive dimensions of sustainability. This is by no means a simple matter of academic positioning: for sustainability to exist we must be capable of conceiving and supporting it.

Contact
guillaume.dezecache@ird.fr

Further reading

Meyer R., Kunreuther H., 2017 – *The ostrich paradox: Why we underprepare for disasters.* University of Pennsylvania Press.

A few fundamentals of cognitive psychology

In simple etymological terms, psychology is the discourse *(logos)* of the mind *(psyche)*. In very broad terms, it is historically and methodologically distinct from philosophy in that it adopts an empirical approach (questions are asked of reality, and reality is expected to supply the answers) and adheres to the scientific method (we seek to establish systematic relations between facts, ultimately by testing hypotheses). In the 1950s, psychology as a discipline was reshaped by the "cognitive" revolution. This perspective hinges on the idea that our only means of accessing reality is through the medium of our cognitive system. Computing metaphors are often invoked to explain this position: the brain functions like a computer, and the mind is the operating system. Our brain-computer has limited storage and processing capacities; the mind-operating system is structured in a certain manner (it only responds to certain types of stimulus; it can only generate certain types of behaviour) and performs very specific functions and tasks by means of mental calculations, much like algorithms. Nevertheless, the brain is notable for its plasticity: it evolves over the course of its life (maturing, then ageing), and is capable of learning. The mind - the operating system - is thus shaped and formed by our social experiences. It is not, however, a *tabula rasa*, a passive, blank slate for sensory experience. The brain needs to "know" what to learn in order to learn anything. The cognitive turn in psychology has taught us much about our psychological and behavioural tendencies. Perhaps most notably, it has revealed out tendency to rely on "heuristics" (otherwise known as "biases"), particularly when performing routine tasks or when we are under pressure to make a decision. For example, we tend to want to confirm things that we already know or believe to be true, rather than seek out information which might contradict these assumptions. These heuristics exist for a reason: they allow us to manage our day-to-day lives. They may, however, be at odds with our sustainability objectives.

Cognition and risk

The story of Thai meteorologist Smith Dharmasaroja (Meyer & Kunreuther, 2017) offers a particularly striking illustration of the potentially harmful effect of heuristics on sustainable development decisions. In 1998, Smith lobbied the government to install early warning systems for tsunami detection, a step already taken by many other Pacific nations. The authorities refused, citing the prohibitive costs involved. In 2004, an earthquake generated tsunamis which swept across the Indian Ocean, wreaking havoc on the Thai coast and killing thousands. While the factors which influenced the government's decision were necessarily complex, it is possible that their reasoning was led astray by heuristics. One form of heuristics, well known to economists, is *hyperbolic discounting*, or the tendency to prioritise immediate rewards (e.g. avoiding the expense of installing an early warning system) over future benefits, even when the latter far outweigh the former in simple, objective terms (i.e. avoiding thousands of deaths and hundreds of millions of dollars' worth of damage). This form of cognitive "short-sightedness" is also evident in our attitude to insurance policies: the number of

people taking out insurance tends to increase after natural disasters, before rapidly dropping back to its previous level even though the risk remains high (Meyer & Kunreuther, 2017). This is closely connected to the psychological phenomenon known as "simplification," which causes people to believe that they are prepared for certain risks (a hurricane, for example), whereas in reality they have only scratched the surface of the recommended preparation measures.

The bad reputation of cognitive sciences

Perusing the reference files devoted to sustainability science on the IRD website (https://www.ird.fr/les-fiches-references-science-de-la-durabilite), it soon becomes clear that psychology and cognitive sciences are often excluded from the conversation. We should not take offence at this omission: our community (or at least the French-speaking chapter) has not really "put in the work" required to claim that seat at the table. In fact, researchers in the cognitive sciences are sometimes held in low regard by colleagues in the social sciences, a reputation which is not entirely unmerited. By acknowledging the fact that our brain is the product of a long process of evolution, and remaining open to research in the field of genetics which hints at connections between polygenic inheritance and cognitive tendencies, we risk giving the impression that our brain is "fixed" and "deterministic," and that its development is impervious to social and cultural influences. Nothing could be further from the truth. Individual behaviour is shaped by individual social experiences, and we are constantly being influenced by the norms and situations we encounter. Moreover, because we concern ourselves with analysing the brain - an organ safely lodged inside our skull and thus protected from the outside world - we often regard the individual as our default unit of analysis. But this "methodological individualism" can lead us to neglect, or overlook entirely, the social influences which are fundamental to the choices we make. When it comes to issuing recommendations, we generally prefer to do so in the form of "nudges," little individual incentives to prepare for future risks, or to recycle our tin cans so that global warming doesn't hit 3°C. In doing so, we distract attention from systemic problems - such as poor communication between systems of governance, or major inequalities in carbon footprints - and leave individuals to bear the burden of change which needs to happen at a much more systemic level. Last but not least, psychology as a field is overwhelmingly based upon research conducted in North America and Europe. It should thus come as little surprise that its conclusions prove to be of little use to anthropologists and sociologists working in and with the Global South. Psychology and the cognitive sciences are largely dependent upon a "positivist" epistemology, which leaves little room for local knowledge and alternative epistemologies.

Psychological and cognitive sciences for sustainability: the scientific, institutional and civic stakes

If, like me, you are convinced that psychological and cognitive sciences can be of great use in matters of sustainable development, then

we need to help these sciences to develop and flourish in the French-speaking academic community concerned with sustainability science. This will undoubtedly demand a certain amount of educational outreach on our part (see my comments above on the "bad reputation of cognitive sciences"), but the social sciences community must also be willing to hear us out. One initiative with which I have been involved personally is the organisation of occasional presentations by researchers in psychology and cognitive sciences, for the benefit of the various IRD Knowledge Communities. This requires a certain understanding of the stakes of sustainability science among the academic community in the fields of psychology and cognitive sciences. The creation of the "psysustainability" mailing list (psychology and cognitive sciences for sustainability, see: https://listes.ird.fr/sympa/info/psydurabilite) constitutes a first step in this direction. We also need to ensure that our knowledge, methods and research are disseminated and developed in the Global South. Initiatives (such as Busara, https://www.busara.global/about-us/) do exist, but they need to be institutionalised. Last but by no means least, we have a real civic duty to share our psychological and cognitive expertise with the general public. In France, initiatives such as "Acte Lab" (https://www.modernisation.gouv.fr/files/2022-04/) have been launched to bring together networks of experts committed to the ecological transition, and these efforts must now be secured for the long term by professionalising the connections between the scientific community and civil society.

KEY POINTS

The configuration of our cognitive system can have a decisive influence on the decisions we take on matters of sustainability. Studying cognition is always going to be useful, because whenever humans are required to take decisions for themselves and others, the risk is that they will fall victim to defective reasoning or psychological tendencies which are incompatible with our sustainability objectives. Nevertheless, studies of the human mind have long been largely restricted to scientific communities in the Global North, and this represents an obstacle to their dissemination and their pertinence for sustainability science.

Global health challenges and solutions: what can sustainability science bring to the table?

Andres Garchitorena,
IRD, UMR Mivegec, Montpellier, France

Background

Half of the world's population has no access to essential healthcare services, and the majority of infant deaths in Sub-Saharan Africa are caused by illnesses - diarrhoea, malaria, pneumonia - for which cheap, effective treatments are available. For example, oral rehydration therapies for children with diarrhoea can prevent death in 90% of cases, but only 4 in 10 children have access to these products. So why are these well-known, effective treatments not working? One major problem is that these seemingly simple solutions actually require complex systems of care provision whose component elements - trained healthcare professionals, infrastructure, equipment and stocks of medicines - must all be present at the point of treatment in order for them to be effective. Sustainability science, which promotes integrative approaches, represents an excellent opportunity to identify and engage with these key global health challenges, working closely with governmental partners and civil society.

Contact
andres.garchitorena@ird.fr

Further reading

Kruk M. E. *et al.*, 2016 – Transforming Global Health by Improving the Science of Scale-Up. *PLOS Biology*, 14 (3): e1002360. https://doi.org/10.1371/journal.pbio.1002360

Challenges of scale: improving the monitoring and control of infectious diseases at the local level

In the 2000s, the Millennium Development Goals provided impetus to the development of "vertical" health programmes designed to control or eradicate specific diseases such as malaria, tuberculosis and HIV/AIDS, contributing to significant reductions in the rates of mortality and morbidity associated with these conditions. In the meantime, significant progress was achieved in the modelling of these diseases at the national and international levels, made possible by the great quantity of public data available and advances in analytical methods. Our understanding of control policies and their implementation was thus enhanced. For example, modelling methods now allow us to identify the most high-risk zones, to predict future trends, and to simulate the impact of different interventions on the incidence and mortality rates associated with these diseases. Nonetheless, there is still a sizeable gap between our collective analytical capacities and their actual application to solving problems on the ground in areas suffering from extreme poverty and high death rates. In reality, the public health authorities responsible for disease control within a given health district are not always equipped with the information they need to adapt national programmes to their local context. In order to ensure that the latest modelling techniques lead to interventions which are effective on a local scale, we need to see closer cooperation between governmental actors and civil society (health ministries, NGOs etc.), working to adapt methods of data gathering and analysis to very precise spatial parameters, ensuring their operational pertinence, while using the results of scientific research to develop decision-making tools.

Methodological challenges: evaluating interventions aimed at strengthening healthcare systems

In spite of the importance of such vertical programmes for tackling certain diseases, it is of utmost importance that we also invest in primary healthcare systems with sector-specific (or horizontal) approaches such as health systems strengthening (HSS), aimed at reinforcing all of the pillars which uphold healthcare systems (human resources, infrastructure, inputs and materials) at all levels (from local communities to national structures), and universal health coverage (UHC), designed to ensure access to quality healthcare for all. The WHO estimates that, in order to attain the health-related SDGs, almost three-quarters of all the extra investment needed in low and middle-income countries in the period 2015-2030 must be allocated to HSR, UHC and other horizontal approaches - equivalent to 300 billion US dollars every year. This amounts to a paradigm shift, since these approaches require us to rethink the evaluation methods we use to inform the allocation of funds and ensure effective implementation at both national and international levels. The gold standard of impact assessments is the randomised controlled trial (RCT), which has been enormously popular in recent decades as a means of evaluating new vertical interventions before they

A path typical of those used by people in the Ifanadiana district (south-east Madagascar) to reach health centres. In this mountainous region, where the road network is limited, three quarters of the population must walk for more than an hour to reach their nearest health centre.

are scaled up. Horizontal interventions such as HSR, on the other hand, are more complex by their very nature, requiring specific contextual adaptations and reshaping healthcare systems at multiple levels, with cross-cutting benefits for the population. With this in mind, establishing solid systems of data collection and analysis (e.g. prospective and quasi-experimental observational methods), operating in parallel with the myriad HSR pilot projects currently running in developing nations, offers a major opportunity to conduct rigorous research at reduced cost, providing proof of their impact in a diverse array of real contexts. Such is the goal of the *Ifanadiana Health Outcomes and Prosperity longitudinal Evaluation* (Ihope) programme, operated since 2014 by NGO Pivot in the south-east of Madagascar, in partnership with the IRD, Harvard University and the National Statistics Institute. The study has already yielded solid evidence of the benefits that HSR approaches can have for rural populations.

Challenges of data availability: optimising geographical access to healthcare in Madagascar

Our research under the aegis of the Ihope cohort study has demonstrated that, in spite of the substantial progress made by the HSR pilot project established by the Public Health Ministry and Pivot in Ifanadiana, the availability of healthcare in hospitals and medical centres - even when that care is of a high standard, and free of charge - does not necessarily mean that care is accessible, especially if patients must walk for several hours to reach it. These

findings have inspired us to develop innovative approaches to reinforcing local community health programmes. These approaches rely upon having people within the community who are qualified to provide certain basic care services, one of the principal methods of expanding the geographical accessibility of healthcare. As community health programmes occupy an increasingly prominent place within national health systems, there is a growing groundswell of interest in how to optimise these initiatives. For example, the WHO recommends optimising the target population and workload of community health providers, with reference to the local context and the size of the population falling within their remit. Geographical optimisation is already common practice in many sectors (e.g. Postal deliveries), using algorithms which are more than 50 years old. Unfortunately, the lack of publicly available, high resolution mapping data (of buildings, footpaths etc.) for rural parts of low and middle-income countries represents an obstacle to the use of such tools in community health programmes. With a view to creating decision-making tools for local stakeholders, we conducted a participatory mapping campaign using *OpenStreetMap* in collaboration with the *Humanitarian OpenStreetMap Team* (HOT), succeeding in mapping over 100,000 buildings and 20,000 km of footpaths in the Ifanadiana district. Using these data, we have been able to integrate geographical optimisation algorithms and: 1) calculate distances, journey times and optimal routes to healthcare services for all households in the district; 2) identify optimal locations for future community hubs and health centres; and 3) determine the necessary resources and optimal itineraries for door-to-door community health services. Scaled up, this approach could have applications beyond the field of healthcare, allowing for the geographical optimisation of other interventions (e.g. educational initiatives) aimed at boosting the sustainable development of rural populations.

KEY POINTS

Integrative, multidisciplinary and solution-oriented approaches, of the kind championed by sustainability science, can help us to identify and tackle key global health challenges. These challenges are dependent on context and include, among other things: the disparity between the scale on which research operates and the scale on which operational actors need support with their interventions; the mismatch between blue ribbon research methodologies and the methods best suited to producing new results in key domains; and the inability to make effective use of existing decision-making tools due to a lack of essential data and information.

The concept of the "sustainable city" in the Global South and the spectre of decolonisation

Risa Permanadeli, Center of Social Representations Studies, Indonesia
Irene Valitutto, Paris-I Panthéon Sorbonne, UMR Prodig, France
Martin Aweh, Cervida, PPNDL, University of Lomé, Togo
Innoussa Moumouni, Cervida, PPNDL, University of Lomé, Togo
Marie-Claude Ngando, Université Paris Cité, UMR Ceped, France

Background

The concept of the "sustainable city" appeared towards the end of the 20th century, as a set of general principles which combine to form a malleable object. This malleability should enable us to conceive of the "sustainable city" not as a unique model, but rather as a plurality of sustainable cities, whose "sustainability" is manifested in different ways depending on their specific urban contexts. Among these contextualisation criteria, it is important not to overlook questions of identity. Cities are places inhabited by communities, each with a history and culture which constitutes its distinctive identity. In some countries, colonisation has played an inescapable role in that process of identity construction.

Contact
irene.valitutto@gmail.com

Further reading

Césaire A., 2004 [1955] – *Discours sur le colonialisme. Suivi de Discours sur la négritude*. Paris, Présence africaine.
Fanon F., 1952 – *Peau noire, Masque blanc*. Paris, Le Seuil.
Permanadeli R., Tadié J., 2014 – Understanding the Imaginaries of Modernity in Jakarta In. *Papers on Social Representations*, 23: 22.1-22.33.

Do we need to rethink the construction of our imaginaries to create sustainable cities?

In urban and peri-urban environments, any planned development is built upon imaginaries and representations - the space is conceived, forged and shaped as a step closer to a desirable future (which may be a "sustainable city," or a "smart city," or a "resilient city" etc.). Although there are isolated examples of city planners, designers and architects from the Global South, proudly using and promoting local knowledge in their work (such as Pritzker Prize winners Diébédo Francis Kéré and Alejandro Aravena), these are the exceptions that prove the rule. At a more general level, the experience of colonialism and its aftermath have contributed to the persistence of imaginary representations whereby the Western coloniser remains a model to which one should aspire, a beacon of modernity, whereas knowledge and know-how derived from indigenous sources are condemned to disappear (Permanadeli & Tadié, 2014). In the hope of one day achieving some form of equality - social, political and economic - by emulating their technical performance, former colonial populations themselves perpetuate this idea that the West continues to occupy a dominant position (Fanon, 1952; Césaire, 2004 [1955]). In former colonies, Western knowledge (hegemonic in nature in light of the power dynamics involved) is perceived, consciously or unconsciously, as a font of truth and the only possible path to a certain kind of prosperity. As a result, urban thinking and planning in the Global South has too often failed to consider how this hegemonic knowledge impacts upon local customs, traditions, values and beliefs. The importance of this preliminary analytical phase tends to only become evident retrospectively, when the reception of town planning and/or architectural projects by locals does not live up to the expectations of the developers, often taking the form of poor attendance and a lack of interest and engagement on the part of the local populace. Preliminary reflection on the colonial legacy could help all involved to grasp the fact that building sustainability (broadly defined for our purposes as a panoply of everyday practices and principles which inform the dynamics of territorial fabrication) is not simply a matter of town planning, budget management and political will; there are also important questions of identity at stake.

How can we approach the "sustainable city" concept as a means of escaping postcolonial thinking?

Architectural production and urban development constitute a form of spatial translation of the sociocultural identities of the peoples who inhabit the spaces in question, identities which may be inherited, constructed or desired. In light of these links between identity and spatial development, examining the effects of colonialism on the imaginaries and representations which influence territorial fabrication is a matter of necessity, not least in order to reframe the notion of the "sustainable city" in a decolonialised context, eschewing the universalising tendency in search of a "pluriversal" perspective. The

very idea of decoloniality as a theory invites us to move beyond single, centralising narratives and accept a plurality of narratives and imaginaries, whose existence is equally legitimate. "Sustainable cities" would thus be plural entities, with properties specific to the contexts in which they exist. In these terms, is it possible to parse the notion of the "sustainable city," and is it capable of encompassing the complexity of former colonial territories whose history has consequences for the collective unconsciousness of their populations? Moreover, if we regard "sustainability" as the cumulative outcome of various lifestyles, is it ever possible to talk about building a "sustainable city" without ensuring the involvement of its residents? Should we not rather accept that the involvement of the local populace in urban development processes is essential if the planning, implementation and operation of sustainable cities are to be well-regarded and accepted locally?

Residence Renaissance, a representation born of colonial imaginaries?

The interdisciplinary reflection contained in this article is the fruit of the "4 Seasons" specialist summer school organised by the sustainable cities Cosav in Lomé (Congo), specifically a site visit to the "Residence Renaissance" property development in a peripheral district of the city centre. According to the project architects, present on site, the luxury homes which comprise this residential complex appear to be primarily of interest to international buyers. The weak demand from local people, as well as the aesthetic and the

Floor plan of the Renaissance residence (Lomé, October 2023).

technical specifications of the buildings all seem to embody some of the tensions and contradictions between representation and the reality of demand. This project appears to be redolent of an idea of modernity forged from Western references and transplanted to the Global South with no effort to adapt it to the local socioenvironmental context (large bay windows likely to create a greenhouse effect, reinforced concrete structure with no insulation or ventilation etc.). While these grand, reinforced concrete villas may confer a certain social status upon their future inhabitants, their spatial composition and the materials and techniques used to build them are harbingers of lifestyles which have little to do with local customs.

Construction in progress on the Renaissance residence (Lomé, October 2023).

KEY POINTS

The various components of sociocultural identity derived from colonial experience require special attention when it comes to understanding the concept of the "sustainable city." It also seems necessary to deconstruct this concept - challenging its position as a depoliticised toolbox and set of fixed principles - and rethink it with input from local knowledge, acknowledging its political valency and admitting endogenous values for the purpose of its transformation. "Sustainable city" projects in the Global South need to be founded upon empirical realities, not preconceived notions. On a strategic level, the implementation of such projects should always be preceded by a study of the sociocultural status quo, in order to evaluate compatibility with the local context.

What can genetics bring to the concept of ecological sustainability?

Romain Guyot,
IRD, UMR Diade, Montpellier, France
Rommel Montufar,
Pontificia Universidad Católica del Ecuador (Puce), Ecuador
Cédric Mariac,
IRD, UMR Diade, Montpellier, France

Background

The study of biodiversity, from identifying living creatures to decoding their genomes, is an important asset for Agenda 2030. Sustainable Development Goals 2 (Zero hunger) and 15 (Preserve and restore terrestrial ecosystems) both include targets which mention the importance of genetic diversity for sustainability: "Maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species" (Target 2.5); "Promote fair and equitable sharing of the benefits arising from the use of genetic resources and promote appropriate access to such resources, as internationally agreed" (Target 15.6). In light of this, the development and transfer of genome analysis methods should be a major priority in order to ensure the sustainable management of resources and keep us on track to hit the Agenda 2030 targets.

Contact
romain.guyot@ird.fr

Further reading
https://www.ird.fr/psf-bioandes-2021-2023

Genomics for sustainability

Human activities have already led to a considerable deterioration in the genomic diversity of life on earth (the shrinking diversity of cultivated plants, the extinction of isolated populations etc.), to the detriment of the biosphere, our own living conditions and those of all other forms of life. By emphasising the interconnections between social, economic and environmental systems, sustainability science promotes practices which preserve natural resources, protect biodiversity and maintain the equilibrium of ecosystems for present and future generations. Profiling the biodiversity of ecosystems by identifying their constituent species, genes and biomolecules is a prerequisite to understanding the way they work and are organised. This is an ambitious undertaking, especially when it comes to profiling regions identified as global biodiversity reserves, such as the Amazon rainforest. Recent technological advances in DNA sequencing have brought such studies into the realm of feasibility, thanks in particular to a new generation of sequencing techniques which are of considerable genetic, microbiological and ecological interest for biodiversity studies. This technology allows for direct, precise and rapid identification of nucleic acid sequences in very long stretches of DNA (tens of thousands of nucleotides) using protein pores with a diameter of just one nanometre (also known as nanopores). As well as driving down costs and making sequencing technology more broadly accessible, the compact size of the sequencing tools allows for analyses to be conducted in the field, thus facilitating the study of diversity in remote and inaccessible environments, and raising the prospect of real time monitoring. This technology has the power to reinforce the principles of justice, fairness and inclusiveness in the development of the latest scientific techniques and knowledge for genome research in the Global South.

Making ecosystems sustainable

The acquisition of genetic data has become key to our comprehension, monitoring and management of natural environments. One of the most recent, and most spectacular, developments has been the possibility of acquiring genetic data from environmental DNA (or eDNA), extracted from samples of water, air or soil rather than directly from living organisms. Faster, non-invasive and often more efficient than traditional sampling methods, over the past decade eDNA nucleotide sequencing has been very widely used to track the colonisation patterns of invasive species, detect pathogens, cryptospecies and elusive species, and to identify communities of species and profile their spatial and temporal variation. Last but not least, cataloguing biodiversity at the molecular level allows us to establish connections between anthropic activities – urbanisation, pollution, introduction of exotic species etc. – and climate change, as well as observed or anticipated ecological disturbances. On a general level, eDNA data are essential for steering conservation efforts and the sustainable management of ecosystems, and ultimately in order to safeguard their sustainability.

Developing teaching and training in bioinformatics

Over the past decade, the development of new genomic analysis techniques has considerably reduced the cost of sequencing and led to the creation of vast databases of genetic sequences which continue to grow exponentially. The increasingly common use of big data applications highlights the fact that the use of new genomic techniques for sustainable resource management is ever more dependent on the computing power and bioinformatic capacities at laboratories' disposal. Utilised by scientists from a highly diverse array of academic disciplines, with strong interdisciplinary credentials, bioinformatics has a considerable and growing influence on health, environment sciences and society at large. Effective teaching of bioinformatics thus requires us to develop vital skills pertaining to interdisciplinary collaboration, communication, ethics and critical analysis of research practices, as well as the relevant technical capabilities. Launched in 2021, the structural training project (PSF) Bio_Andes now running in Ecuador aims to boost capacities for analysing genetic and bioinformatic data, in collaboration with partners from Colombia's LMI Bi-Inca unit. In 2023, the first training course on nanopore sequencing techniques was held in Quito, attracting teachers and students from various disciplines (zoologists, botanists, medical scientists, computing experts and bioinformatics specialists). Among other things, the knowledge acquired during this programme will equip them to better understand the genetic diversity of the ivory palm, an endemic species now at risk of extinction which was previously intensively harvested for its seeds. This enhanced understanding of genetic diversity, combined with practices honed in the field, will be put to use to identify female seedlings capable of producing fruit and seeds, contributing to sustainable reforestation efforts. Moreover, work in the field of bioinformatics is of central importance to interdisciplinary research programmes devoted to managing palm trees in Ecuador, encompassing everything from environmental expertise and understanding genetic diversity to the comprehension of cultural practices by means of interactions with local communities. These new skills make the project partners more autonomous when it comes to gathering and analysing bioinformatic data, enhancing their knowledge of local biodiversity and nurturing the development of sustainable agriculture, conducive to better management of genetic resources.

Training session on nanopore sequencing techniques, Quito (Puce, November 2023).

KEY POINTS

The massive acquisition of genetic data constitutes an excellent opportunity to further our understanding of ecosystems and their diversity, allowing for more nuanced assessments of environmental sustainability. Teaching and knowledge transfer by means of strategic training programmes are key actions which are well-received by our partners, educating participants about cutting-edge techniques such as nanopore genome sequencing and data analysis. Finally, ensuring that these techniques and associated instruments are accessible at a reasonable cost is of utmost importance, enabling partners to retain control over biodiversity data collection and analysis within their own laboratories, advancing genome analysis in the Global South in the interests of fairness and inclusiveness.

Women in debt: the invisible cost of sustainability

Isabelle Guérin,
IRD, UMR Cessma, Paris, France

Background

Who owes what to whom? This is a question which underlies many contemporary debates on matters of development and sustainability. It has financial (debt as a sum to be repaid), moral (debt as obligation) and political (debt as a balance of power) dimensions. Concepts such as colonial debt and environmental debt are increasingly cropping up in discussions of the reparations or compensation that former colonial empires, states and extractive industries might be expected to pay for the damage wrought in the past. The concept of patriarchal debt merits our full attention: poor women find themselves in massive financial and moral debt, despite the fact that they provide vital care for children, dependent persons and, in many cases, for nature.

Contact
isabelle.guerin@ird.fr

Further reading

Graeber D., 2011 – *Debt: The First 5000 Years.* Brooklyn, Melville House.

Guérin I. *et al.*, 2023 – *The Indebted Woman. Kinship, Sexuality and Capitalism*. Stanford, Stanford University Press.

Hickel J. *et al.*, 2022 – Imperialist appropriation in the world economy: Drain from the global South through unequal exchange, 1990–2015. *Glob. Environ. Change*, 73: 102467.

Hornborg A., Martinez-Alier J., 2016 – Ecologically unequal exchange and ecological debt. *J. Pol. Ecol.*, 23: 328-333.

Debt in Agenda 2030: a partial vision

The authors of the Agenda 2030 declaration express concern at levels of government debt in the Global South, and recommend that private investors play an active role in financing efforts to meet the SDGs. Agenda 2030 also argues in favour of improving financial markets and providing credit at attractive interest rates to governments, businesses and private individuals. This recommendation is explicitly linked to women in SDG 5, with the idea that better access to financial services will improve their autonomy and "empowerment." Nonetheless, fully grasping the stakes of debt and credit (two sides of the same coin) requires a broader understanding of what debt actually means. Debt is not only a financial injunction (a sum to be repaid), but also a moral (debt as obligation) and a political (debt as balance of power) phenomenon. The history of lending and debt tells us that the most reliable repayers are not necessarily those with the most money, but rather those who have no choice but to repay because the consequences of non-payment are just too heavy to bear; or else those who have internalised a feeling of inferiority which makes repayment a solemn duty (Graeber, 2011). Over the course of history, peasants, craftspeople, the proletariat, poor countries and other dominated groups have always paid their debts, while dominant forces - aristocrats, landowners, managers, bankers, rich countries - have adopted a much more capricious attitude to honouring their debts. Looking at the matter from this angle casts new light on questions of development and sustainability. With countries in the Global South still massively and chronically indebted to the International Monetary Fund (IMF) and countries from the Global North, should we not be instead be talking about the "colonial debt" arising from the exploitation and destruction wrought by the former colonial empires, and the need for compensation (Hickel *et al.*, 2022)? The concept of "ecological debt" is also making headway, arguing that wealthy nations and extractive industries should pay compensation for their disproportionate use of natural resources (Hornborg & Martinez-Alier, 2016). This multifaceted vision of debt also applies to some of its specifically female characteristics, still vastly under-researched in spite of their importance.

Female debt at the heart of contemporary economies

SDG 5 states that women should have better access to financial services and particularly to credit, presented as a tool for business creation and improved management of the family budget. And yet, in many contexts (in both the Global South and Global North) poor women are already heavily in debt just to meet their daily needs: buying food, paying doctors, paying school fees, ceremonial duties, mobile telephone contracts, home repairs, repaying old debts etc. These debts are incurred to offset insufficient and irregular income, rising expenses and the inadequacy or absence of social protection systems. In the absence of gender-specific statistics, female debt is often overlooked. However, numerous ethnographic studies and a handful of specific statistical studies have clearly illustrated the overexposure of women to the risk of subsistence debt,

often expensive and socially demeaning. Most debt comes at a cost, placing a sometimes considerable burden on available income. According to surveys conducted by the Observatory of Rural Dynamics and Inequalities in Southern India (ODRIIS), hosted at the Institut Français de Pondichéry and supported by the IRD, interest repayments on outstanding debts take up an average of 30% of the household income of rural families in Tamil Nadu.

Are women in debt or credit?

Why do lenders target poor, women when they often have less income and little or no capital? In fact, in banking terms they are often regarded as being "insolvent." And yet, poor women are actually conscientious with their repayments, regardless of the sacrifices this entails. They are less mobile than men, and thus more susceptible to societal control. They can count on a mutual support network of family and neighbours. They repay debts in order to maintain their solvency and thus the ability to contract further debts in the future, but also to protect their reputations as respectable wives and mothers. This ethic of repaying debt is inseparable from the norms of femininity, which assign women to the status of inferior, "obligated" individuals who constantly "owe" something - whether to their children, husbands, extended family, community or nation. These norms are inextricably bound up in the ideology and organisational structures of the patriarchy, i.e. based upon the supposed inferiority of women and the perpetuation of male power. Poor women find themselves in massive financial and moral debt, despite the fact that they provide vast amounts of vital care for society as a whole: caring for children,

Financial transaction (at a sort of mobile cash machine) in a Tamil village in India. Large scale "financial inclusion" policies (taken up by SDG 5) work on the assumption that integrating women into financial systems will further their emancipation, while in reality the consequences are much more ambivalent, or even negative, due to the burden of debt repayment.

for dependent persons and also, in many cases, for nature, as a result of the responsibilities they take on for securing food, water and wood for cooking, maintaining pasture land etc. In light of these immense contributions, why are women not regarded as creditors? Because that would require us to recognise the value of the invisible work, connections and care they provide. This would entail a dramatic paradigm shift, upending our understanding of value and prioritising connections, care and interdependency over economic productivity and monetary and market values.

KEY POINTS

Acknowledging the existence and scale of environmental, colonial and patriarchal debt would considerably improve Agenda 2030. Patriarchal debt in particular has been overlooked. What is to be done? Recognising that women are overexposed to debt would be a first step. Recognising the value of the many connecting and caring activities often performed by women is also fundamental; this would amount to regarding women as "creditors" rather than perpetual debtors. This paradigm shift is crucial, not only to combat gender equalities but also to change the way we think about sustainability: we need to replace the old patriarchal ideology which regards connection and care as female obligations, or even ontological features of femininity, with a new ethics which acknowledges that vulnerability and interdependency are ontological characteristics of the human condition.

Protecting marine food systems against the decline of coral reefs

Eva Maire,
IRD, UMR Marbec, Sète, France

Background

The Sustainable Development Goals highlight the economic, social and cultural ramifications of the sharp decline in fish populations as a result of global changes. Coral reef based socio-ecosystems are on the front line of these changes, as over 70% of their current surface area is under threat. Coral reefs are also vital sources of food, as the fish caught in these areas are diverse, rich in essential nutrients and of huge importance to many of the world's coast-dwelling populations. As such, policies are needed to protect coral reefs as local food systems, in order to: 1) safeguard diverse, nutrient-rich diets; 2) support these socio-ecosystems, which are among the most vulnerable in the world.

Contact
eva.maire@ird.fr

Further reading
https://www.ird.fr/voyage-au-coeur-des-recifs-coralliens

Coral reefs: socio-ecosystems under serious pressure

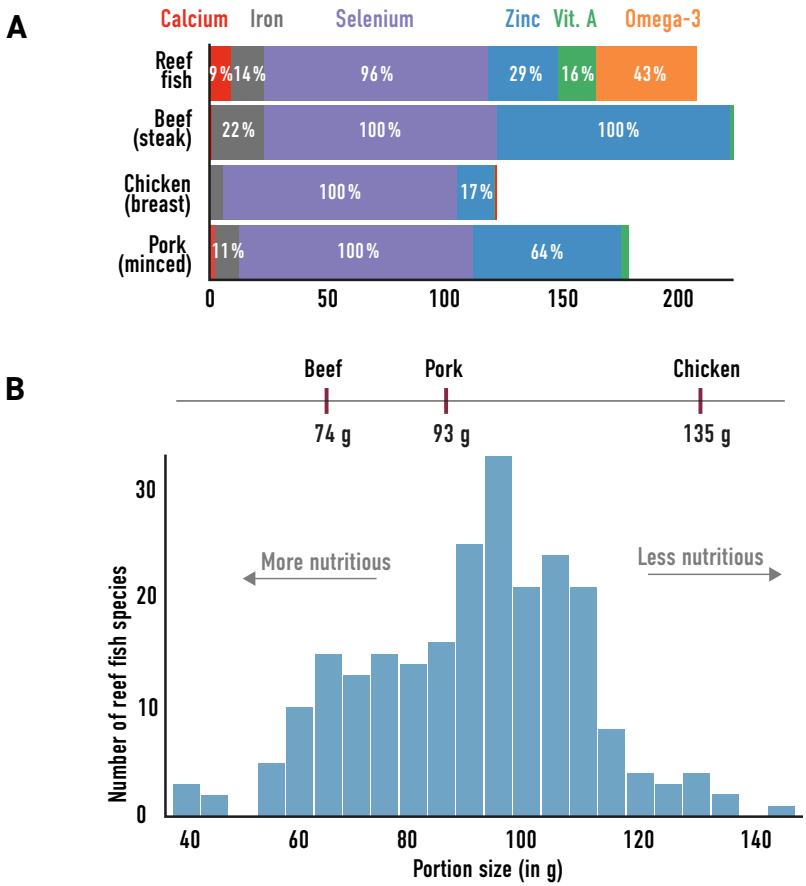
Ecosystems all over the world are undergoing profound changes as a result of anthropic pressures on a vast scale. Coral reefs are among the most vulnerable ecosystems, severely affected by the impact of human activities. Rising sea temperatures are increasing the frequency and intensity of extreme weather events, causing tropical storms and heatwaves which can lead to massive coral die-off. The rapid decline in coral coverage and the accompanying loss of biodiversity are already plain to see in many parts of the world. And yet, the human communities living in proximity to coral reefs are often heavily dependent on the resources they offer for their food, their culture and their means of economic subsistence. Coral socio-ecosystems are thus extremely sensitive to the deteriorating health of the reefs, making them vital case studies for better understanding and engaging with contemporary sustainability challenges.

Coral reefs are home to a multitude of species packed with micronutrients

The incredibly diverse array of fish, invertebrates and molluscs which populate coral reefs constitute an important source of nutrition. Fish, like other foodstuffs of animal origin such as beef, pork and chicken, is rich in bioavailable micronutrients such as calcium, iron and vitamin A, often in short supply in the tropics. Compared with other foodstuffs of animal origin, reef-dwelling fish are particularly rich in vitamin A, iron and Omega 3, as well as containing comparable concentrations of other key nutrients (fig. 1 A). A portion of 90 g of reef fish can provide a child with, on average, 33% of their recommended daily intake of six micronutrients, comparable to 134 g of chicken or 74 g of beef (fig. 1 B). However, compared with foodstuffs of animal origin derived from terrestrial livestock, limited to a small number of species, reefs are homes to hundreds of species of comestible fish, with micronutrient concentrations varying considerably from one species to the next. Just 40 g of the most nutrient-rich species can supply 33 % of an individual's daily dietary requirements, compared with 140 g for the least nutrient-rich varieties (fig. 1 B). Moreover, fish is generally more affordable and more locally accessible than other foodstuffs of animal origin. Furthermore, coral reef fishing communities harvest or catch a diverse array of species using a multitude of fishing techniques. Diets which include a greater diversity of animal species – from land or sea – tend to be richer in nutrients. This is partly due to the increased probability of consuming complementary nutrients, and the fact that different cultures combine seafood with different ingredients, increasing the overall diversity of their cuisine.

What does the future hold for coral reef fishing?

The global decline of coral reefs highlights the challenges involved in preserving local aquatic food systems. Data regarding the impact of climate change on coral reefs suggest that fish populations respond in various ways. The loss of coral cover often boosts seaweed



Nutrient contents of reef fish and equivalent values for foodstuffs derived from land-dwelling animals; comparison for 6 nutrients (calcium, iron, selenium, zinc, Vitamin A and Omega 3). (A) Nutrient density (shown as % of recommended daily intake of six nutrients) of a portion of 100 g of reef fish (average values for 239 frequently caught species), compared with beef, chicken and pork. (B) Portion size needed to provide 33% of the daily recommended intake of 6 key nutrients for a child between the ages of 6 months and 5 years, average for 239 reef fish species compared with meat from land-dwelling species.

reproduction, a boon for those species towards the base of the food chain which eat the weed. This enables parrotfish and rabbitfish, species frequently targeted by fishermen, to develop more rapidly, increasing their biomass and productivity. Recent studies suggest that many species could adapt to the consequences of ocean warming in the short to medium term. With reefs likely to be home to less diverse communities of fish and less complex food webs, many small-scale reef fisheries are already pivoting to target those species which

endure in spite of the decline in coral coverage. Management systems could thus be adapted to take into account the fluctuating productivity of different species in response to climate change, for example by regulating their catches of species such as rabbitfish which feed on macroalgae.

What does this mean for local food policies?

Coral reef fisheries are essential to food security in many regions, hence the need for new policies to ensure that these local food systems can continue to prosper sustainably. To this end, we must begin by maintaining and supporting the diversity of these food systems so that they do not come to be dominated by less nutritious alternatives. Measures could be put in place to promote "territorial" markets which prioritise local food over international commerce. Different approaches are also needed in order to guarantee the sustainability of reef fisheries as reefs continue to decline and consumer demand evolves. This might involve strategies which prioritise nutritionally vulnerable populations and promote traditional diets. More could be done to help fishing adapt to fluctuations in the populations of target species and changing dietary habits among consumers, for example measures to help fisheries update their fishing fleets, as well as efforts to adapt dietary habits to prioritise more resilient species and more sustainable fishing practices.

KEY POINTS

Coral reefs have long been studied for their important ecological, cultural and economic contributions. Nevertheless, the role played by coral reefs in local food systems, although often implicit, is less clearly understood. New policies are needed to protect coral reefs in their capacity as local food systems, and to ensure their sustainability in the face of globalisation, coral deterioration and evolving consumer demand. All of these adaptations are likely to vary considerably from one region to the next, and will require localised collaborations between scientists, managers and stakeholders.

CO-CONSTRUCT

Sustainability science promotes the co-construction of knowledge and practices, based on collaboration between scientists from different disciplines (interdisciplinarity) and non-academic stakeholders (transdisciplinarity), in a participatory and engaged approach. For research and development stakeholders, interdisciplinarity, transdisciplinarity and engagement are not imposed, but emerge from the professional background, attitude, reflexivity and curiosity of each individual.

Intensifying the ecological functions of soils for a more sustainable agriculture: acting with actors

Éric Blanchart & Jean Trap,
IRD, UMR Eco&Sols, Montpellier, France

Background

Soils are of central importance to some of the major issues concerning the future liveability of our planet, such as food security, adaptation to climate change and the preservation of biodiversity. Agricultural productivity, carbon storage and the stability of food webs are all dependent on the vast multitude of organisms which live in our soils. It is estimated that only a quarter of these subterranean species are known to humankind. And yet, this living fabric is all too rarely taken into consideration by agronomic innovators, and often neglected by farmers. IRD researchers and partner academics from the University of Antananarivo have been working to improve the integration of the soil's biological functions into agricultural practices in the rainy Hautes Terres region of Madagascar, boosting productivity, sustainability and resilience to climate change. This long-running collaboration has given rise to a new step-by-step protocol for engaging with local stakeholders, the "Soil Ecology Intensification Cure" (SE-Cure).

Contact
eric.blanchart@ird.fr
jean.trap@ird.fr

Further reading

Blanchart E., Trap J., 2020 – Intensifier les fonctions écologiques du sol pour fournir durablement des services écosystémiques en agriculture. *Étude & Gestion des Sols*, 27: 121-134.

Soil biodiversity: a resource in need of protection

Soils are among our planets most diverse milieus. The physical and chemical complexity of our soils supports a vast array of habitats and a multitude of organisms, from bacteria and fungi to nematodes and worms. These organisms interact in complex networks and, ultimately, allow terrestrial ecosystems to function. Soils and the biodiversity they support form one of the central pillars of sustainable agriculture as defined by the Food and Agriculture Organization (FAO): efficient use of natural resources, management of nutrients, water and pests. The efficacy of agroecological practices is dependent on their capacity to manage soil biodiversity in such a way as to boost its ecological functions: freeing up nutrients for plants, capturing carbon, limiting pathogenic agents, regulating the flow of water etc. Farmers with a good understanding of their soils who use suitable agricultural practices can be a positive force for biodiversity.

Co-diagnosis

The first step in the SE-Cure process consists of a localised diagnosis at plot and farm level, analysing soil dysfunctions and associated pedological, sociological, ecological and agronomic constraints impeding the sustainability of agricultural operations. Identifying such problems requires interdisciplinary approaches in order to involve producers in the process of cataloguing and analysing, by means of

Examples of organisms found in soils
(*Atlas de la biodiversité des sols*, GSBI, 2015/Joint Research Centre [European Commission]).

Workshop for the co-construction of innovative practices integrating soil biodiversity in Madagascar.

surveys and workshops, traditional practices and obstacles to agricultural production. This phase should also include soil profiling analyses for farms. Surveys and soil quality diagnoses in the Hautes Terres region of Madagascar revealed that agricultural output was being held back by: 1) the poor fertility and lack of biological activity in the soils; 2) economic constraints endured by farmers, who were unable to buy the necessary inputs, as well as the lack of fertilisers on farms

Better understanding the workings of the soil

Our knowledge of the way soils work - and particularly the relationships between biodiversity, biotic processes, ecological functions and ecosystem services - remains too limited to predict the impact of agricultural practices on the workings of agrosystems. The second phase of the SE-Cure approach aims to fill this gap by conducting experiments in laboratory settings or in the field, inoculating organisms into the soils and restoring habitats to study the determinism of their biological functions. In Madagascar, for example, research focusing on upland rice has shown that certain organisms in the soil (earthworms, microorganisms and nematodes) perform important functions such as releasing bioavailable nutrients for plants, protecting crops from bioaggressors, capturing carbon in the soil and maintaining soil structure. For instance, we have demonstrated that the presence of earthworms increases the phosphorous content of plants by 87% compared with conditions in which worms are absent. This research demonstrates the advantages of restoring soil biodiversity and intensifying its functional contribution to agrosystems.

Testing innovative agricultural practices in response to soil dysfunctions

The aim of this phase is to identify agricultural practices which serve to intensify the ecological functions of soils and improve the agronomic performance of farming systems. The approach adopted is based on inter- and transdisciplinary participatory research involving sociologists, agronomists, ecologists and farmers. This phase incorporates co-learning workshops exploring both scientific and traditional knowledge of soil functions, as well as workshops co-designing measures to restore the biological functions of soils, while also taking socioeconomic constraints into account. The trials arising from these workshops focus on different agronomic approaches to restoring the ecological functions of soils, including

organic and mineral fertilisation, plant diversity, genetic selection and biofertilisation. Fertilisation has emerged as a promising avenue for further exploration, combining organic and mineral fertilisers with beneficial organisms (bioinoculation) in order to resolve the fertility issues affecting some of Madagascar's upland agricultural soils.

Co-evaluating the effects of agricultural practices and disseminating the results

The final phase of the SE-Cure approach consists of co-evaluating the agronomic performance of innovative systems and aligning them with the ecological intensification of soil functions. Agronomic performance is assessed from the perspectives of both the farmers and the participating scientists. The tools used to measure the intensification of ecological functions in the soils must be perfectly calibrated to the local context, and the dysfunctions identified at the outset of the process. They are forged over the course of the three preceding phases in the SE-Cure process, and are in no way generic or pre-defined methods. The innovative practices selected at the culmination of this process are communicated to those directly concerned (farmers, politicians etc.) by means of pamphlets and booklets written in the local language, as well as workshops presenting the results to users and summary documents aimed at political decision-makers, and of course media coverage, social media posts and academic communications.

KEY POINTS

The co-construction of agricultural practices optimising the biological functions of impoverished soils represents a contribution to the food security of small farmers. Working with stakeholders upstream of the agroecological innovation process, and throughout the process of implementing new scientific approaches, makes it possible to build and apply innovative practices for improving the sustainability and resilience of agrosystems. With biodiversity in decline on a global scale, there is now an urgent need to improve our fundamental understanding of soil biodiversity and its effects, identifying and assessing agronomic factors on a local scale which can allow us to steer biological interactions in the soils for the purpose of reinforcing food security. The SE-Cure approach is an attempt to rise to this challenge. It has proved its worth in the context of upland agriculture in the Hautes Terres region of Madagascar, and could profitably be transferred to other contexts.

Equitable research partnerships: putting theory into practice

Alice Chadwick El-Ali & Maggy Heintz,
UK CDR, United Kingdom

Background

Complex, interdependent societal, environmental and economic challenges are undermining our capacity to deliver on the Sustainable Development Goals (SDGs) by 2030. In order to successfully rise to these global challenges, we need to see more collaboration between disciplines, fields of activity and regions of the world. This is precisely the spirit of Target 17.6, contained in SDG 17: "Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation, and enhance knowledge sharing on mutually agreed terms." There is no getting around the fact that the international research ecosystem is founded upon imbalances of power and unequal access to resources and opportunities. The equity of North-South research partnerships has been increasingly scrutinised over the past decade. This has been a result: 1) of concerns over the need to decolonise knowledge and research; 2) the growing recognition of the impact of research (management, actors) on development.

Contact
m.heintz@ukcdr.org.uk

Further reading

Essence & UK CDR, 2022 – *Quatre approches pour encourager les partenariats équitables de recherche.* UK-CDR_ESSENCE_Equitable_Research_Partnerships.pdf
IRD Best Practice Guide. ird.fr/sites/ird_fr/files/2020-06/GBP.pdf

How do we define an equitable partnership?

The term "equitable partnership" has become unavoidable in the development research world, frequently employed by financial backers and research institutions in the Global North to signpost their commitment to forming fair partnerships with stakeholders in the Global South. But what does it mean exactly? In 2019, at the International Research Development Funders Forum (IRDFF) co-organised with the Science Granting Councils Initiative in Sub-Saharan Africa (SGCI, sgciafrica.org), participants agreed on a definition of equitable research partnerships which requires "mutual trust, mutual participation and mutual responsibilities and benefits for all partners, with equal value placed on each partner's contribution" (Essence & UK CDR, 2022: 8). This definition sets out a number of common principles for the formation and development of partnerships but, in practice, equity depends on the context and the power dynamics between partners, resources and the time available, as well as the overall objectives of the partnership.

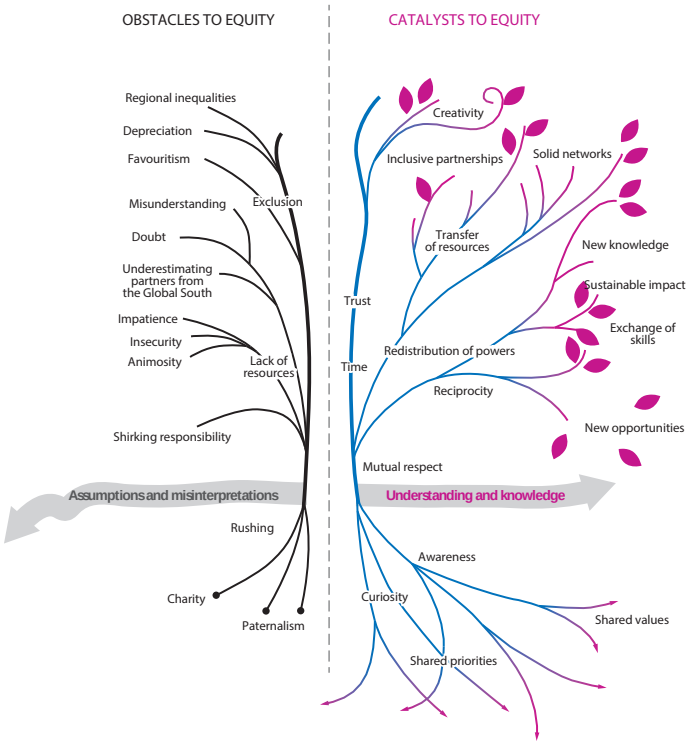
Catalysts and obstacles to equitable partnerships

In 2021, UK CDR (the UK Collaborative on Development Research) conducted a global survey of research funders and practitioners with a view to compiling a best practice guide. Analysis of the results of this survey has identified various catalysts and obstacles, both tangible and intangible, to achieving equity in partnerships. These factors are often mutually reinforcing, and are summarised in the tool known as the equity tree. Intangible factors include cultural openness, shared values and the systems of knowledge production they underpin, mutual respect and trust. These intangible factors are also dependent upon tangible changes in practices, such as the sharing of resources and opportunities, and adjustments to research conditions to ensure that they are not dictated by the partner with the most power and resources.

Funders and research institutions facing up to the need for change

In order to put theory into practice, how can funding bodies and research institutions create an environment conducive to making fairness integral to research partnerships? To begin with, a holistic approach is required, changing the way in which research is funded, conducted and managed across the ecosystem. Many of the obstacles to equitable practice are structural in nature: financial resources to cover indirect costs and the time taken to set up collaborative arrangements, allowances for the cumbersome work of due diligence etc. We now need to see changes being made by funding agencies, institutions and research teams (Essence & UK CDR, 2022).

Funders have a role to play in the construction of a partnership ecosystem conducive to the sharing of power and resources. This will require: 1) adapting modes of funding to make subsidies conditional upon the equity of partnerships, with mechanisms which ensure the availability of the time and resources required for partnerships to emerge, and for co-creation processes to prosper, along with direct funding for researchers and institutions in the Global



The equity tree.

South which will allow them to lead multinational research projects and consortia; 2) supporting efforts to reinforce research systems in low-income countries, with respect and humility, promoting mutual comprehension in both Northern and Southern contexts; 3) devoting special attention to research management and administration, which are often major sources of inequality in North-South partnerships - this also applies to efforts to strengthen research capacities, requiring a coordinated approach from funding partners - ; 4) establishing partnerships with funders, governments and institutions in the Global South with a view to steering decision-making processes and support for development research to make it better aligned with priorities in the Global South.

While many of the changes required of funders will necessitate coordinated action, on the institutional side a few specific changes may suffice to introduce more equity to research partnerships, by means of institutions' collaboration strategies. This will require: 1) drafting guidelines and institutional policies to improve equity (e.g. insisting upon the joint drafting of collaboration agreements as a necessary prerequisite when forming partnerships, providing research support staff with the necessary

training and resources); 2) investing in long-term institutional relationships to bolster the sustainability of partnerships beyond the financing stage; 3) involvement with research management networks, and helping partners in the Global South to develop their management capacities; 4) creating opportunities for South-North and North-South interactions between staff, nurturing a better mutual understanding of the research contexts involved; 5) streamlining contract processes, taking into account the various institutional capacities and needs in play, while remaining attuned to differences in the rules applicable to the partners in terms of financial transfers, due diligence, intellectual property rights and administrative burdens.

For researchers, we need to see changes to the research culture in order to fully appreciate the importance of equity in partnerships with the Global South. This will require a real determination to change existing practices, and a willingness to question hierarchies of power and knowledge. This will require: 1) evaluation of the differences in capacities and resources available to research partners, followed by the introduction of mechanisms to redress these imbalances and track progress in this domain; 2) the integration of mutual learning mechanisms, South-North and North-South, into projects and collaboration agreements, ensuring that learning and development opportunities are shared equitably; 3) developing the skills required to support transdisciplinary research, involving non-academic partners in the co-development and co-execution of projects and prioritising the pertinence, utility and impact of research results; 4) equitable co-publication policies, along with fair representation in activities arising from the impact of the research (innovation, spin-offs, public policy connections etc.).

KEY POINTS

A paradigm shift is required within the international research ecosystem. We need to put equity firmly at the heart of the political, regulatory and financial processes put in place to support development research partnerships. Equitable research partnerships help to make research programmes more pertinent to the communities concerned, as well as reinforcing research systems, promoting diversity of knowledge and experience and opening up new solutions. Funders, institutions and researchers must work together to develop and integrate mechanisms designed to reinforce equity in their research partnerships, in order to tackle the systemic development challenges facing the world today.

Fishing in the Amazon: play first, negotiate later

Marie-Paule Bonnet[1], Neriane N. da Hora [2, 3], Kevin Chapuis [1], Christophe Le Page [4], Pierre Bommel [4], Joine Cariele [2], Gustavo Melo [5], Stéphanie Nasuti [2][1]

Background

From the international Conferences of the Parties (COP Climate and Biodiversity) to local agreements between users sharing resources, reaching consensus in multilateral negotiations is a challenge of primary importance to sustainability efforts. It has also become a dynamic field of research within the scientific community, as well as among political scientists and IT specialists. One example of this kind of research involves fishery resources in the Amazon basin, where local communities have a long history of collective organisation to ensure sustainable management. Highly diverse though they are, fish stocks are in sharp decline in certain parts of the Amazon as a result of climate change, environmental factors and industrial fishing. In some Brazilian states, such as Pará, community agreements are often violated. In such cases, fishing becomes a source of conflict.

Contact
marie-paule.bonnet@ird.fr

Further reading

CHAPUIS K. *et al.*, 2022 – Support local empowerment using various modeling approaches and model purposes: A practical and theoretical point of view. *in* Marcin C. (ed.), K. Bogumil (ed.): *Advances in Social Simulation*. Proceedings of the 16th Social Simulation Conference, 20-24 September 2021, Cham, Springer: 79-90. https://link.springer.com/chapter/10.1007/978-3-030-92843-8_7

Support modelling: facilitating system transformation

The purpose of support modelling is to encourage collective learning about the workings of socioecological systems, focusing on the use of natural and renewable resources; it may be explicitly focused on transforming practices in response to pre-identified problems. It involves stakeholders in the co-construction of models based on interactions between autonomous agents (e.g. fishermen within a community), and encompasses a vast array of formats ranging from role-playing games (or RPGs) requiring no computers to digital simulators (or multi-agent systems) used in participatory mode with all involved. The co-construction of models highlights the coexistence of different points of view concerning resources, and the potential for conflict between these views. The process aims to arrive at a shared vision conducive to informed collective decision-making, allowing for changes in the way resources are used within the existing system. The use of models makes it possible to operate at a certain remove from reality, making it easier to explore potential avenues for transformation identified by the group, and encouraging collective debate. Often simple in form, the model is a snapshot of the group's shared "vision"; it is not a predictive tool. Co-construction is an iterative, evolving process; it starts with a series of questions which evolve as the process continues, and may lead to the emergence of further questions.

Fishery resources in Amazonia: a source of competition and conflict

Managing fishery resources is a societal challenge well-suited to support models. In Amazon, subsistence fishing is the primary source of animal protein for populations residing on flood plains, and the main source of income for small scale fishing communities. The impact of industrial fishing on fish stocks has prompted the populations living in proximity to the great rivers to organise themselves with a view to limiting, or even prohibiting, access to floodplain lakes. This has caused considerable conflict in the region. In the state of Pará, fishing is regulated by a 2004 law which fishing communities now regard as outdated, a recurring source of conflict. In 2021 the state government set about revising the community fishing agreements, henceforth the new legislative standard for fishing regulations. The government tasked representatives of small scale fishing communities (unions, fishery councils) municipal environmental secretaries and representatives of the State of Pará with supporting this process.

A serious game to encourage dialogue and negotiations

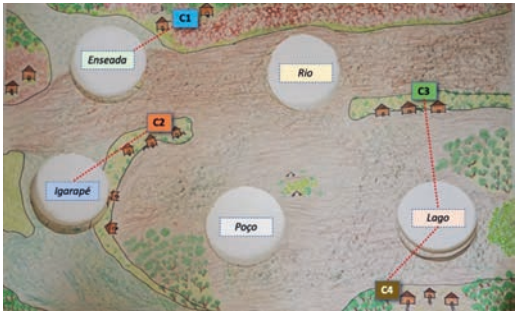
Within the framework of the Bonds (Biodiversa-Belmont Forum) and Saberes (BNP Paribas Foundation) projects, an interdisciplinary Franco-Brazilian team set out to create a support model for tackling the influence of climate

1 • [1] IRD, UMR Espace-DEV, Montpellier, France; [2] University of Brasilia, CDS, Brasilia, Brazil; [3] NGO Sapopema, Brazil; [4] Cirad, UMR Sens, Montpellier, France; [5] Eicos, Federal University of Rio de Janeiro, Brazil.

change and the installation of dams to protect fisheries, seeking adaptation strategies to better preserve these milieus. However, during preliminary discussions ahead of the project launch, the local fishing union based in Santarém, in the West of Pará, proposed refocusing the modelling efforts on intra- and inter-community agreements, in order to better respond to the demand from local people. A focus group bringing together researchers, representatives of the NGO Sapopema (Society for fishing and environmental protection), local fishing unions, the Amazon Fishermen's Movement, rural workers' unions and representatives of the federation of community associations met monthly over the course of a year to co-construct a role-playing game called "Pesca Viva", which has since been tested and approved by several communities in the region.

From the Pesca Viva game to revised agreements on a regional scale

The co-construction of the game brought to light the problems faced by small scale fishing communities, such as the colonisation of fishing grounds by industrial fishing operations, the lack of fish stock monitoring and the inadequacy of the punitive measures applicable when agreements are violated. It also demonstrated the importance of strengthening the governance of local institutions and communities, and the need to communicate more effectively on the importance of preserving resources. A decisive step in the modelling process was the successful pivot to expand the focus group by involving municipal environmental representatives and the Pará state



The Pesca Viva game (August 2022).

government, in order to re-establish dialogue and trust between these governmental institutions and the representatives of fishing communities. By their own account, the dynamic established by this process paved the way for negotiation of a historic agreement for the region, spanning all three municipalities. One secretariat of Brazil's Ministry for the Environment has also made use of the game as part of their Pescando Cidadania programme, encouraging local people to respect the periods in which fishing is subject to restrictions in the region. The rules of the game are as follows:

two boards are laid out containing five fishing zones, reflecting the seasonal variations experienced by the flood plain. Four stocks of fish, two of which are protected, are dealt out. A year is played over three rounds - winter, summer and the "*defeso*" period in which protected species of fish cannot be sold. The game features four communities, each represented by a group of players who take on the roles of fishermen. They can move, fish and sell their catch, and use the money to buy food and goods. In each group, one player acts as community leader. The four fish stocks reproduce and migrate. At the end of a year, the model (SMA) which accompanies the RPG is used to reproduce the behaviour of the players for four more years. Once the resulting effects on fish stocks are calculated by the model, the community leaders are invited to come to an agreement. The game facilitators do not give any particular instructions. The players then play for another year, and the multi-agent simulator once again calculates a projection for the ensuing four years.

KEY POINTS

In the Brazilian state of Pará, local fishing communities on the banks of the Amazon are more concerned about the damage wrought by industrial fishing than they are about climate change or the proliferation of dams. Participating in a co-construction exercise run by researchers - a support modelling project - has prompted them to rethink their initial objectives, although this does not mean that they cannot return to them later. The process has delivered tangible results, restoring interinstitutional dialogue and bringing users and political decision-makers closer together, contributing to the negotiation of a regional fishing agreement. The researchers adopted an intermediary position in this process, utilising a methodology which promotes the exchange of knowledge and fosters the formation of bonds of trust.

Participatory research and sustainability science

Mina Kleiche-Dray & Maël Goumri,
IRD, Society & Globalisation Department, Marseille, France

Background

In France, research projects in which institutional researchers collaborate with the very people whom they seek to study have proliferated since the 2000s. Such participatory approaches to research are of special pertinence to sustainability science, with its commitment to the co-construction of research structures, getting all actors involved in order to profoundly reinvent scientific practices. Participatory research exists on a spectrum which encompasses research, mediation, expertise and open science, reinvigorating the dialogue between science, research and society with new epistemological, methodological and institutional challenges for science.

Contact
mina.kleiche-dray@ird.fr

Further reading

Goumri M., Kleiche-Dray M., 2022 – *La recherche participative au sud face à son institutionnalisation. État des lieux et perspectives*. Marseille, IRD, 40 p.

Participatory research and the challenges of North-South inequality

Participatory research is a way of doing research "differently." Known by various names (participatory science, participatory research, collaborative research, citizen science, co-research, community based research etc.), programmes of this kind belong to a broad family of scientific mechanisms whose common denominator is to involve research subjects in the research conducted by institutional researchers (CH), in order to benefit from the different forms of knowledge contributed by these non-professionals. The places and methods used for such research initiatives - such as fablabs (fabrication laboratories), science shops, citizen observatories and "science in society" programmes - allow for fruitful exchanges between the "dominant" force of science and other forms of knowledge. In the Global South, research which seeks to proactively engage with local people is now firmly at the heart of many national policy agendas (for example in Bolivia, Ecuador and Mexico), with a view to building more inclusive societies where the epistemic balance between scientific and non-scientific, and between North and South, is a subject of central importance. At the international level (COP summits on climate and biodiversity, declarations of the rights of indigenous peoples, peasant farmers, people of African descent etc.), the knowledge possessed by local peoples is recognised as an important technical and political solution to global challenges. Whether that means indigenous peoples or women, on account of their close connection to the environment (for sustenance, care, habitat), certain sources of wisdom are recognised for their capacity to develop specific forms of knowledge (experiential, secular, erudite) on human and non-human subjects; this knowledge has a central role to play in protecting biodiversity and adapting to climate change. Moreover, participatory research projects led by actors with different worldviews, discourses and practices contribute at a more general level to reducing the verticality of knowledge and the asymmetries of power it may engender. Such approaches acknowledge epistemic justice as a major social priority. Above and beyond the manner in which participatory research is conducted, the key question is how to effectively integrate knowledge from different sources.

Participatory research and the colonial legacy of knowledge v. epistemic justice

Participatory research approaches taken on special significance in the Global South, in light of the postcolonial context. For many institutional researchers, such approaches may appear to offer solutions for moving beyond the "colonisation of knowledge," i.e. the constitution of knowledge on the South from the North, in the interests of the imperial powers. Participatory research can help institutional researchers to better align their work with locally identified priorities, making it a major asset to sustainability science. The interventional research programme 'Transitions', led by the Transvihmi unit and the Enfants VIH Afrique paediatric network in Senegal and Burkina Faso, offers a fine illustration of the ways in which involving non-professionals in

research can help to recalibrate objectives and activities to better address the priorities of the people directly concerned. As part of the Transitions programme, a participatory workship was established and operated with 16 young participants living with HIV, with a view to identifying their specific needs and challenges. Inclusive exercises (ice breakers, anchoring, meditation), the use of collective intelligence tools (problem trees) and an improvisational theatre session all helped to create an atmosphere in which participants felt free to speak. The young participants were also able to discuss the everyday challenges of living in a society which discriminates against people living with HIV. These discussions made it clear that the most pressing need was not for more sexual and reproductive health education, as the project had anticipated, but rather to break down the barriers of social isolation and fight back against self-stigma and discrimination. The project's young partner charities are currently running two community projects addressing these themes. By encouraging the co-construction of technical and political solutions to global challenges, sustainability science also revives old questions about partnered research and reminds us of the importance of ensuring that research is conducted "with the South" rather than simply "in the South." This includes involving non-professional participants in research. In the case of the IRD, participatory research is increasingly being used in the construction of knowledge communities in order to "systematically co-construct our research programmes and projects by building bridges for multi-actor dialogue, championing different forms of knowledge and creating spaces for informed, fair and equitable exchanges" (Contract of Objectives, Means and Performance). In sustainability science, the co-construction of research mechanisms must involve all actors in order to thoroughly revitalise scientific practices (avoiding the risk of simply "bolting on" or adding a "sprinkle" of alternative expertise), integrating "third party researchers" every step of the way (from programme design to data dissemination) and promoting interdisciplinarity (particularly between "hard sciences" and the social sciences).

From scientific mediation to research mediation

The push to formalise closer relations between science, research and society also features on the agenda of many national, European and international organisations (e.g. the UN's annual international conference on participatory research). This movement implicitly requires the co-production of knowledge and the emergence of a third sector for research, comprising citizen collectives and other civil society actors. In France, co-research and co-construction of multi-actor knowledge now occupy an important place in efforts to revitalise research and innovation strategies and policies and promote scientific progress more broadly. This new dynamic has the support and encouragement of the Ministry for Higher Education and Research, under the aegis of the national research strategy set out in the road map "Science with and for Society." This document encourages the sector to strengthen dialogue between science, research and society by establishing research programmes which involve non-professionals in research activities, making them more inclusive of different

groups and creating spaces where science and society can meet and interact. This is no longer simply a matter of scientific mediation, but instead of research mediation. Participatory research and the structures which make it possible are thus of central importance to efforts to involve non-scientific actors and transform scientific practices, with implications for the processes of knowledge production and utilisation, and access to data. This movement represents a new chapter for the dialogue between science, research and society.

Participatory research at the heart of an equitable, solidarity-led partnership

Participatory research has certain implications for research practices. Existing within a continuum which encompasses research, mediation, expertise and open science, bringing their own specific contributions in terms of horizontality and public participation, such research practices can help to renew research questions and subjects, as well as the science-research-society dialogue and matters of research governance, guidance and evaluation. The ANR Gengibre project is a fine example: coordinated by Cessma since 2021, the project seeks to nurture dialogue on the agricultural practices employed by different populations in Brazil, by means of a participatory agroecological study. This dialogue serves to promote ancestral knowledge, bringing academic knowledge into direct contact with local knowledge produces and perpetuated by women. The project is also illustrative of emancipatory approaches to science, and feminist angles in particular, producing and utilising knowledge to bring about social transformation which prioritises the sustainability of agricultural practices as well as gender equality. Such approaches are at the forefront of ongoing debates in scientific communities all over the world, on account of the epistemic and methodological stakes they pose for science as a whole. Sustainability science carries the promise of a renewal of scientific practices, a transformation wherein interdisciplinarity, multi-actor engagement and structural mechanisms occupy a central role in the co-construction of research and educational initiatives in and with the Global South.

KEY POINTS

Sustainability science invites us to question the capacity of our system of scientific production to revitalise the relationship between the natural and social sciences, as well as its attitude to "other" forms of knowledge, in order to rise to socioenvironmental challenges. This requires a structural development of research practices which begs the question of how exactly we define participatory research, while also raising important institutional and ethical questions for research systems, since these practices necessarily have consequences for the people involved.

The ambivalence of low carbon research with partners in the Global South

Sylvie Fanchette,
IRD, UMR Cessma, Paris, France
Nadège Letourneur,
Université Paris Cité, Paris, France
Emmanuel Pannier,
IRD, UMR Paloc, Paris, France

Background

Many French laboratories have already set about making their research less carbon-intensive, making the low carbon transition with the help of tools, mechanisms and help from research support organisations sharing key expertise. Labos 1point5 and Ma Terre en 180 minutes (www.materre.osug.fr) are two collectives of lecturers, researchers, engineers and research technicians committed to making research more sustainable. Nevertheless, this process of transition must not undermine the fundamentals of research work in the Global South. It must be guided by discussions between partners, and with their consent. It is important to assess the pertinence and potential benefits of systems in place in France with reference to the context of research and teaching in the Global South, in a spirit of equitable partnership.

Contact
sylvie.fanchette@ird.fr

Further reading
Gratiot N., 2022 – « Ensemble pour le climat ». *In*: *Sustainability Science*, Marseille, IRD Editions: 158-162.

A reflexive workshop in Vietnam

During the annual general assembly organised by the IRD in Vietnam in November 2020, attended by our Vietnamese partners and CIRAD, the question of what can be done at the individual and institutional levels to reduce our environmental impact was discussed. We also heard about a number of "low carbon" experiments launched by Vietnamese research institutes, including limiting the number of emails sent and their recipients, the importance of remote seminars and meetings, limiting single use plastics etc. With IRD research missions put on pause by the Covid pandemic, partnered research programmes had to be rescheduled, leaving more time for data gathering by Vietnamese researchers, and the involvement of expatriate researchers to help with the work left by colleagues who returned to France. Nonetheless, this remains a highly sensitive subject for our Vietnamese partners, particularly when it comes to potential restrictions on their international professional travel. The historic responsibility of the Global North for accumulated CO_2 emissions in the atmosphere is something which crops up in discussions with partners.

Following this meeting, a training programme spanning three half-days was organised to share best practices using the serious game "My Earth in 180 Minutes" (35 participants, of which 1/3 were Vietnamese). This programme raised awareness among IRD personnel and partners of the climate and environmental impacts of research, the urgent need to address them and the role of researchers in this challenge. Various initiatives launched by French laboratories were discussed, including examples from the laboratories making their transition with support from Labos 1point5. These discussions helped all involved to gain a better understanding of the opportunities and obstacles facing the implementation of concrete solutions, including travel, digital resources, competition between labs and researchers, overproduction of data, and inequality of access to resources among laboratory members and partners. Five groups were formed to play a serious game simulating the work of a fictitious international joint laboratory working in the field of oceanography in South-East Asia. The level of awareness of environmental changes and the climate impact of research proved to be very uneven. This highlights the importance of foregrounding initiatives of this kind in IRD operations overseas, where participants come from a variety of disciplinary backgrounds, including academic partners from the Global South as well as local staff.

Adapting the serious game My Earth in 180 Minutes for the Vietnamese context

A number of proposals were made as to how to adapt this tool to the institutional, relational and hierarchical context of Vietnam. At some of the tables, our Vietnamese partners were more inclined to bow to the authority of the laboratory or university. Most of them found it more difficult to portray a forceful or careerist character; they were willing to answer questions, but not comfortable with speaking up spontaneously. More contextualisation was required to tailor the game to their

needs. In Vietnam, governance is primarily a top-down affair: there is much deference to age and experience in negotiations and decision-making. Discussion is possible, but managers have the final word. Decisions are often taken based on perceived financial or institutional outcomes, rather than scientific or academic benefits. The game in question has a researcher as its central character, whereas in Vietnamese laboratories individuals have less decision-making autonomy. In order to adapt to this cultural context, the My Earth game can be played in teams or pairs so that players feel more comfortable making the necessary choices. It is also possible to add new player profiles. Another point to be considered is that the calculator used to calculate carbon footprints in the game is not pertinent to the Vietnamese context. The game's climate calculator does not include air conditioning or motorbike travel, two things which are very widespread in Vietnam. Similarly, there are substantial differences between France and Vietnam when it comes to electricity production; it is less carbon-intensive in France, because of the country's nuclear power capacities. Finally, alternatives designed to limit overseas travel, including attempts to make missions longer and fit more activities into each trip, were problematic for Vietnamese academics: it is difficult for them to get away for more than a week, as they must find funding to pay for substitute lecturers to cover their teaching responsibilities. One Vietnamese lecturer proposed to contribute to the creation of a new virtual team for the Ma Terre game, representing a Vietnamese laboratory or university department for whom power balances, access to funding, the academic calendar and the responsibilities of members are different from those familiar to French laboratories. It is vitally important to take account of regional specificities and North/South inequalities, in order to avoid perpetuating and/or accentuating them.

Debate within the climate expert community

In order to build upon these discussions with our Vietnamese partners, a dynamic debate was held in Montpellier at the Climate Knowledge Community event, focusing on a fairly loaded question: "Will reducing the carbon footprint of laboratories exacerbate inequalities of access to research resources and means within laboratories and with our partners? " Several important lessons emerged from the discussions:

- the carbon footprint of research is not a priority for many of our colleagues in the Global South. They are faced with other, more pressing problems such as: 1) freedom of movement and the difficulty of obtaining visas to visit France; 2) low wages which, in some countries, are detrimental to their living standards and research and teaching practices; 3) brain drain to the Global North, due to instability and the lack of resources;
- opportunities do exist to transfer skills and redefine roles within project teams so as to limit the need for researchers from the Global North to travel into the field personally (training the trainers); by the same token, advances in video communication technologies have made knowledge more accessible to researchers and teachers from the Global South;

• some laboratories (e.g. Locean) have experimented with reducing the emissions of their researchers based in the Global North, without applying the same rules to partners in the Global South working on the same programmes; this indicates a certain sense of environmental justice;

• the funding available to researchers in the Global North often encourages travel, and the sums cannot be reallocated to other activities such as skills transfer and training. This raises questions as to the suitability of funding policies, which encourage travel without broader consideration of the requirements of partnered research and the social and political circumstances faced by some researchers in the Global South;

• it would now appear to be essential that we tackle the question of unequal access to resources within partnerships in a collective spirit, in order to better define the priorities of partners in the Global South and how they differ from those of the Global North. A survey (or situational exercises using serious games) involving partners from the Global South would serve to gather their opinions on which sources of emissions need to be preserved in order to keep partnerships running, at a time when IRD researchers are being asked to cut down on travel.

Our two day workshop at the Cosav Climate conference heard some very enriching exchanges on the subject of the low carbon transition and the "My Earth" tool. Thanks to the contributions of several partners from the Global South, a new virtual team has now been formed for the purpose of simulating "Hydrometeorological Modelling in Argentina and South America." Reflexive workshops, serious games and dynamic debates are all good ways of spotting points of ambivalence and constructing new paths for positive, equitable collaboration.

KEY POINTS

Embarking upon low carbon research projects with partners from the Global South is a complex undertaking, on account of the weight of the colonial legacy and the ecological debt owed by the Global North. It has become clear that dialogue with partners concerning the stakes of co-production raises delicate questions of values, positioning and legitimacy: it is important that we avoid being perceived as "preachy" or imposing a "top-down" orthodoxy. We cannot study social and environmental inequalities without first discussing the inequalities which exist within laboratories and between partners, raising the question of how we should use the ecological "savings" made by cutting down on travel. These savings must be managed collectively, even when budgets are specific to individual partners.

Analysing one's partnership style in co-constructed and co-directed projects

Manuelle Philippe,
Université de Bretagne Occidentale, UMR Amure, Brest, France

Background

The experience of co-constructing and co-leading scientific projects and initiatives focusing on the challenges of adaptation and managing environmental changes could benefit from a more reflexive approach to partnerships and the roles of the respective partners. With this in mind, it is important to have an analytical methodology in place which enables us to: 1) clarify the missions and commitments of all members of the partnership; 2) hold pre-launch discussions in order to avoid potential conflicts of legitimacy between partners during the execution phase; 3) identify any areas which might not be covered by the partnership; and 4) reassure partners with regard to any expectations emanating from other partners during the project which they might consider to be misplaced. The analytical framework proposed in this chapter serves to identify the different dimensions of partnerships, on the one hand, and the partners involved, on the other.

Contact
manuelle.philippe@univ-brest.fr

Further reading
Macher C. *et al.*, 2021 – Towards transdisciplinary decision-support processes in fisheries: experiences and recommendations from a multidisciplinary collective of researchers. *Aquatic Living Resources*, 34: 13.

The different dimensions of partnerships

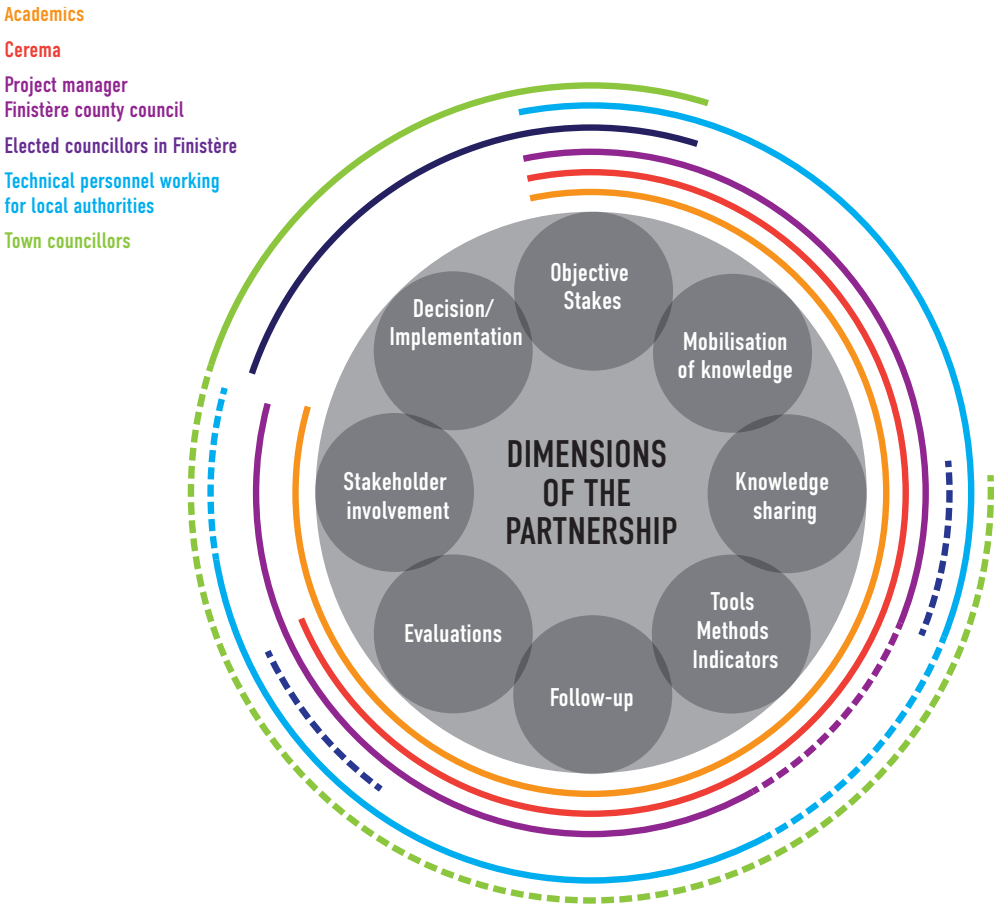
Partnerships involve eight major structural dimensions. The first and only one of these dimensions which must necessarily be shared and accepted by all partners is the object or purpose of the partnership. That purpose may be defined collectively, or arise from the converging interests of different partners who agree upon an initial position, based on a proposal put forward by one of their number. Mobilising knowledge means gathering and making use of the knowledge and data available in academic studies and the expertise of all actors (partners and stakeholders with an interest in the object of study). This serves a dual purpose: 1) Establishing a joint diagnosis of the question at hand, the current state of knowledge and the territory concerned, shared by all partners; and 2) sharing knowledge beyond the circle of partners, in order to establish a common foundation of knowledge upon which the rest of the process can build. The theoretical design, creation and mobilisation of tools, methods and indicators are often informed by the academic literature, but the choices made and the actions taken to implement them would not be possible without the support of other partners connected to the local context. Such collaborations determine the pertinence and success of partnership programmes, at the operational level. Inter- and transdisciplinarity are conducive to the hybridisation of tools and methods, eschewing academic conventions in favour of greater cohesion with operational targets and contexts.

Further downstream, project follow-up should consider both the technical execution of the project and the manner in which the partners interact. Project governance can thus be handled in-house, or else with the help of external input from a monitoring committee, scientific advisory board or steering committee. Evaluating the societal impact of a project generally obliges us to think on a different time scale from that used for the purposes of the scientific project (however, consider the example of projects with an interest in change theory: Castella J.-C. & Blundo Canto G., 2023 – 'Participatory theory of change and the agroecological transition' i*n*: *Sustainability Science* Vol. 2, Marseille, IRD Editions: 182-185). Evaluation is often an ex post exercise, conducted once decisions have been taken - if indeed a political decision is taken following the scientific project, which is not always the case. When projects deliver social innovations (changing practices, raising awareness or sharing knowledge), their effects are even more difficult to measure as they belong to the long term. Such evaluations may be quantitative or qualitative, if indeed they exist. The structuring of scientific research into discrete, successive, time-limited projects is hardly conducive to such long-term evaluations. On the contrary, with long term partnerships it is easier to analyse the impact of projects on society. Another important dimension is the extent to which the involvement of local stakeholders (other than members of the partnership) helps to anchor projects/initiatives to local issues, tying them to the territory and its realities. In France, researchers occupy institutional roles and play no part in operational decision-making, management

or implementation. This is not the case in all countries, and in some cases researchers may be closely involved with decision-making. Depending on the context and the issues in play, decision-makers may be elected officials, professional organisations or local associations.

The involvement of partners

The degree of integration of the various members of the partnership can be visually represented using a diagram of the kind shown here, with concentric rings of different colours. Using one circle to represent each partner, we can visualise the major (solid lines) and minor



Analysis of the Litto'Risques partnership (dimensions and involvement of each member).

(dashes) commitments, and the dimensions to which partners do and do not contribute. The example shown here concerns an institutional partnership in the Finistère *département* focused on coastal risk management in the context of climate change (the Litto'Risques partnership). Academics are here amalgamated into a single group, although the team in fact comprised researchers from four different disciplines (geography, geomorphology, economics and social psychology). A decision was made to lump them together because they constitute a well-established group with shared working habits and an internal governance conducive to interdisciplinarity. In another context, we might easily imagine using a different circle for each academic discipline or position (normal v. post-normal science). Circles may thus be used to represent a group (academics) or a person occupying a specific role or mission (e.g. the representative of the county council), either because that person is the only one with the post in question (as is the case here), or else because unique characteristics mean that they cannot be assimilated into a larger group. The various dimensions of the partnership can be adapted to fit the context, and the involvement of partners may vary over the course of the project. If such changes come about as the result of transparent exchanges among partners, they can form a sort of social contract, conducive to the pursuance of the project and its transformative impact. Nevertheless, this analytical framework, and the partnerships involved, may be destabilised by a factor not discussed here: responsibility. When the research object involves a risk (natural, technological or human), the time allotted for the project may be too short in relation to the time needed for decisions to be reached in matters where decision-makers' responsibilities are on the line.

KEY POINTS

When establishing partnerships in the field of sustainability science, there are two invariants which are ever present: the first dimension (defining the object of research) and the final dimension (reaching a decision, or implementing it if the project proceeds to this phase). Above and beyond good intentions, a successful partnership requires special attention to the constraints, interests and ambitions of all parties. This requires a certain amount of flexibility and social innovation, and is ill-suited to conceptual or organisational rigidity. This is all the more true when the different dimensions of the project are not necessarily successive - some run throughout the duration of the project, while others involve iterative processes. One last point of fundamental importance is that partnerships are often founded upon strong interpersonal relationships and bonds of trust.

Joint field work, a catalyst to transdisciplinarity

Sow Papa Gueye Sow [1], Antoine Baigue [2], Manon Balagi [3], Stéphanie Dos Santos [4], Ernest Haou [5], Jean-François Léon [6], Anastasia Mendy [7], Zohra Mhedhbi [8][1]

Background

Cities are increasingly vulnerable to global changes, especially cities in the Global South whose capacity to adapt is limited. Hence the need to thoroughly rethink existing models of urban planning and management. With this context in mind, the second thematic workshop organised by the Sustainable Cities knowledge community (Cosav), held in Lomé, Togo in October 2023, brought together more than fifty scientific and non-scientific actors from a broad variety of backgrounds to discuss some of the most pressing urban issues in a spirit of transdisciplinary collaboration. In order to facilitate collaboration among this multi-actor group, we experimented with a change of collective working methods based on collective intelligence.

Contact
papagueye.sow@ird.fr

Further reading

https://www.cosavvillesdurables.xyz/

Dos Santos S. *et al.*, 2022 – 'Shared fieldwork: fertile ground for interdisciplinary research into cities in the Global South' in: *Sustainability Science*, Marseille, IRD Editions: 96-99.

What are the benefits of a joint approach to field work?

During the second thematic workshop organised by the Sustainable Cities knowledge community, participants worked on four different field studies with a special focus on the concept of the participatory and inclusive city: the sacred forest of Lomé, the Aneho urban park, the technical landfill centre and the "Caisse" real estate development in Lomé. This joint approach to field work involving both scientific and non-scientific actors was important on two fronts: firstly, because it prompted the scientists to think outside their interdisciplinary bubble and open up to other actors, and secondly because it provided a platform for multi-actor dialogue. Moving beyond the "coordinated fieldwork" concept (Dos Santos *et al.*, 2022), one of the goals of this exercise was to facilitate cooperation between different stakeholders while avoiding conflicts of interest between actors, a common feature of coordinated fieldwork. For example, the first field project focusing on the sacred urban forest site in Lomé shed light on the competing interests in play: while political actors were keen to promote the economic potential of this protected forest, in terms of its tourist appeal and potential to attract visitors, the customary chief was more concerned with preserving the sacred status of the place and maintaining his role, refusing to negotiate the strict restrictions on access to the forest (between 2 and 3 a.m., clothes are forbidden so as to allow for a closer connection with nature). The academic researcher, meanwhile, interpreted these conditions as an exclusionary act, something which was not borne out by testimony from local people. If it is not effectively channelled by methods capable of capitalising on the creative potential of disagreement, confronting divergent or opposing viewpoints in this manner will not necessarily lead to a consensual solution. This is why coordinated fieldwork prioritises transdisciplinary and cross-cutting approaches, and is not afraid to stray beyond the usual boundaries of academia. Joint field projects are thus less concerned with the object of the research than they are with the dialogue which occurs between actors, aiming to achieve a convergence

A methodological means of deconstruction and reconstruction

With shared fieldwork, diversity of perspectives is the name of the game. With coordinated fieldwork, on the other hand, a methodological approach promoting convergence is resolutely to the fore. Coordinated fieldwork thus creates a space for dialogue and action, wherein academic and non-academic fields of expertise and skills are not hierarchically organised. Within this space, assumptions can be deconstructed and reconstructed. The aim is to establish a coordinating framework within which participants feel free to share their knowledge and understanding of the

1 · [1] UFR LSH, Leidi, UGB, Saint-Louis, Sénégal and UMR LPED, IRD/AMU, Marseille, France; [2] DRI, IRD, Marseille, France; [3] Dmob, IRD, Marseille, France; [4] UMR LPED, IRD/AMU, Marseille, France; [5] Cervida, UL, Lomé, Togo; [6] Laero, CNRS, Toulouse, France; [7] UMI Source, Ucad, Dakar, Sénégal; [8] UMR Prodig, IRD, Paris, France.

Display on the theme of urban sustainability at the Lomé thematic workshop (October 2023).

topic being studied. In this respect, the field work done at Lomé's technical landfill centre (CET) offers an informative example. Bringing together scientists from different disciplines allowed this project to combine and compare perspectives from public policy analysts, spatial theorists and experts in concrete matters such as atmospheric pollution and the drainage of chemical compounds into the water table. This academic approach was enriched by the expertise brought to the table by the managers of the CET facility, along with external experts in reuse and innovation project management. These combined perspectives allowed for the emergence of a coordinated project to more effectively reuse household waste upstream of the CET.

Best practices for joint field work

This coordinated approach need not necessarily be limited to fieldwork. It is an invitation to work more immersively, prioritising collective learning. Such methods test the ability of group members to work together, and thus to trust one another. That sort of trust takes time. Activities of this kind are only suited to residential seminars lasting several days, where every activity from breakfast through to dinner is a collective undertaking. This proximity is conducive to transdisciplinary collaboration on a very concrete level. Collaboration can also take shape before and after the fieldwork proper, in the form of reflexive workshops prioritising

collective intelligence. For example, after the field visits a number of groups were formed in order to continue working with the help of tools such as the "world café" game, "memories of the future" and the "5 Whys". The latter tool is particularly revealing of the way in which individual perceptions of past experiences gradually evolve to reveal the profound motivations behind decisions (or else to identify the root causes of problems in need of lasting solutions), becoming a driving force for future actions. Integrating the social, cultural and artistic dimensions is also invaluable. As well as creating connections and adding some rhythm and dynamism to affairs, the inclusion of Togolese songs and dances helped to convey some key messages at the concluding presentation seminar, especially for actors who had not taken part in the thematic workshops. Activities like this help provide a break from the formal, strictly institutional perspective, encouraging multi-actor exchanges while anchoring discussions in the context of the urban socio-ecosystem.

KEY POINTS

Multi-actor dialogue is now a key priority for the future of urban sustainability in the Global South. Coordinated fieldwork offers a pertinent framework for steering these discussions, in a process of permanent co-construction and reconstruction. Focusing on a shared space, coordinated fieldwork brings together academic and non-academic actors to explore, in a very fruitful process, the reasons behind their disagreements; this permits them to identify convergent solutions, all while respecting the diversity of their viewpoints. This approach needs to be backed up with a collaborative approach, ideally in an emotionally stimulating setting, employing a socio-constructivist methodology which prioritises collective intelligence while remaining flexible enough to adapt to the context.

Developing disaster science as a means of reducing risks

Julien Rebotier [1], Pascale Metzger [2], Jean-Mathieu Nocquet [3], Pablo Samaniego [4] & Laurence Audin [5][1]

Background

A disaster may be defined as the harmful realisation of a risk befalling a given territory. In order to attenuate such disasters, a solid understanding of existing risks is every bit as important as other factors such as governance, institutional capacities, inequalities, economic models etc. SDG 13 stipulates the introduction of measures to combat climate change and reduce the risk of natural disasters. Drafted under the aegis of the United Nations, the Sendai Framework was adopted in 2015. This framework attaches special importance to advancing knowledge. However, experience shows that the knowledge generated by research in earth sciences and social sciences is often ill-suited to the demands of risk management and minimisation. What we need now is a research strategy that is better aligned with the scope for and obstacles to action, a more interdisciplinary approach which remains open to non-academic stakeholders.

Contact
julien.rebotier@cnrs.fr

Further reading
https://lmi.igepn.edu.ec/

Science and the constraints of management

Traditionally, scientific discussion of risk has focused on threats and vulnerabilities, two key terms which symbolically represent the division of labour between the physical sciences (the study of threats) and the social sciences (more concerned with vulnerabilities). In this dichotomous view, the evidence of extant threats (earthquakes, volcanic eruptions, floods and the like) often obscures the importance of the social and political dimensions involved in the construction of risk. And yet, rather than a simple succession of threats and vulnerabilities, the lessons of past disasters point to a complex interplay of physical events and social and political phenomena. As such, in order to produce knowledge of practical use for risk management, a change of approach is necessary: we need to focus not on what threatens us, but rather on what we want to protect, i.e. the key functions of our territories, given concrete form by the places and relations which enable these functions to exist: political power, the supply of energy and food, health, education etc. Analysing the vulnerability of these major priorities requires us to identify all of the risks which could potentially interrupt or disrupt their operational continuity.

This includes, but is not limited to, exposure to potential threats. It must also take into consideration other sources of weakness (technical, legal, economic, political…). By doing so, the concept of risk becomes more than just a combination of threats and vulnerabilities, resting instead on two key pillars: major priorities, and their vulnerability. This approach to risk analysis allows us to focus on those places and objects belonging to the social sphere which allow our territories to function, priorities for which public authorities might be willing to establish vulnerability prevention and reduction policies. It offers a way of constructing research objects and questions which incorporate the influence of context, territorial specificities and the constraints of risk management.

Towards a disaster science which is sensitive to context

Disaster science is an umbrella term encompassing an array of research approaches aimed at better understanding and managing risks in their territorial contexts. Much of this research is conducted in an integrated manner, by means of: 1) interdisciplinary practices conducive to mutual reconceptualisation and reformulation, transcending the traditional boundaries between social sciences and physical sciences with regard to "risk" as an object of study; 2) transdisciplinary practices sensitive to existing constraints and cognisant of the conflicting interests of the many actors involved; 3) recognition of the nature of research work, and the conditions which inevitably have consequences for the type of knowledge produced. Exploring an alternative research agenda, disaster science foregrounds two key aspects: firstly, the diversity and complementarity of disciplinary contributions; secondly, contextual effects arising from the conditions

1 · [1] UMR Tree, Bayonne, France; [2] UMR Prodig, Aubervilliers, France; [3] UMR Geoazur, Nice, France; [4] Magma and Volcano lab, Clermont-Ferrand, France; [5] UMR Isterre, Grenoble, France.

in which research is conducted and the constraints and opportunities associated with its results. Disaster science is not limited to contributions focusing on the study of risk and its components. It requires both an opening up and a contextualisation of research, in order to arrive at a knowledge strategy which is better aligned with the specificities of the territories directly affected by risks and the challenges implicit in their management. The aim of such research is to prevent or mitigate the impact of disasters.

In Ecuador, a high standard of scientific research and the dilemmas of insufficient integration

In the fields of geosciences and the social sciences, three decades of cooperation have nurtured the emergence of a binational research community in Ecuador, united by a shared language and more than capable of debating research priorities. This community is now grappling with the relative failure of the knowledge it produces to bring about real change with regard to risk conditions. There appear to be a number of obstacles standing between knowledge and action. Some of them have to do with the ways in which scientific knowledge is produced. In the past, funding allocation has tended to prioritise high level research in the most cutting edge disciplines, leaving interdisciplinary and cross-disciplinary initiatives to the care of a few tenaciously motivated collectives. Others arise from the contexts (social, institutional, political) in which the knowledge they produce subsequently circulates. Obstacles to risk reduction are not simply a matter of insufficient knowledge. Most vulnerability diagnoses are a matter of public record, as are the mechanisms in play and the cartographic profile of the principal threats. This apparent impotence of academic knowledge when it comes to actually reducing risks points the way for the work to be done by disaster science: to construct a research agenda which incorporates the social conditions of knowledge production and the various constraints (social, political, institutional) which influence the production and circulation of knowledge.

The challenge of doing research differently: developing disaster science in Quito

Coming up with an alternative strategy for our knowledge of risks is particularly relevant to one aspect of research work, that aspect directly concerned with the constraints and opportunities of fieldwork and the conditions of risk management. Research needs to be more integrated and more horizontal, working to complement other disciplines' readings of risk components. A good understanding of the threats at hand will define the relevant time frame and spatial reach. Understanding institutional response capacities will also determine the technical potential for action. In spite of the competition between different knowledge strategies (means, skills, time), disaster science should not be viewed as a rival to other disciplinary studies of risk components. This means acknowledging the need for more openness, inter- and transdisciplinarity, but we also need to construct the modes and methods which will allow disaster science to be more than a field pieced

together from practices and skills borrowed from elsewhere. To that end, we propose one prerequisite condition and three concrete proposals for making research practices more integrated, more reflexive and more contextually aligned with risks. Firstly, we must establish on a permanent basis opportunities for exchanges between researchers from different disciplines, and between researchers and non-academic stakeholders. Such opportunities are essential for building mutual understanding, so important to the task of interdisciplinary conceptualisation. Transdisciplinary exchanges can help us to keep in mind the conditions in which actions unfold, although this does not mean that research should simply be aligned with the demands of management. The goal is to identify the knowledge required to reduce and manage risks within specific contexts. There are three avenues to explore here:

- reappropriating existing knowledge with the help of more horizontal readings enriched by inter- and transdisciplinary exchanges. The goal is to integrate the contributions of all parties, based on concrete examples and translated into shared research subjects. Disciplinary skills are deployed on the basis of the contribution they can make to resolving jointly-defined problems;
- integrating disciplinary contributions with the help of general principles, such as systems dynamics and questions of scale. The use of models and scenarios can help to situate experience gained in the field, putting it into perspective in a manner conducive to effective action and more robust cross-disciplinary knowledge;
- structuring methods and the construction of research subjects in disaster science. Adopting a programmatic approach which seeks to build, on foundations provided by concrete cases and experience, the forms and content of a new and singular science.

KEY POINTS

When it comes to reducing the risk of disasters, scientific knowledge is at once essential and insufficient. Disaster science encompasses every aspect of risks, where they originate and how to study and manage them. Disaster science seeks to reconfigure the risk research community to achieve more overlap and more permeability between the research sphere and society at large. In this context, the key challenge attendant upon the creation of an entirely new research agenda consists of constructing methods of knowledge production which are sensitive to the constraints of the social world and the corresponding possibilities for action. In Quito, the close bonds of trust built up between research, cooperation and management actors gravitating around the IRD community for more than 40 years make this territory fertile ground for the development of such initiatives.

TRANSFORM

The ambition of sustainability science is to find answers to some of the great challenges facing our planet, contributing to the acceleration of the transformations our societies must undergo in order to face up to global changes and interconnected crises. In light of this, the world of higher education and research for sustainable development needs to reflect on how it can contribute to this global effort.

The digital TRANSFORM of African universities: opportunities and challenges for the SDGs

Maïssa Mbaye,
Université Gaston Berger, Senegal
Gaoussou Camara,
Université Alioune Diop, Senegal
Hélène Kirchner,
Inria, France

Background

As is the case all over the world, digital tools and services are in the process of transforming African societies and economies. In spite of persistent problems with connectivity and access to electricity, the expansion of digital technologies is bringing with it new services and new sources of innovation and opportunity which are especially relevant to the Sustainable Development Goals (SDGs). West African universities thus provide an interesting insight into the stakes of digital development, as well as opportunities to transform innovations into drivers of sustainable development. In order to realise this potential, however, key players in higher education and research in West Africa must back the transformation and the accompanying changes.

Contact
gaoussou.camara@uadb.edu.sn

Further reading
https://ace-partner.org/dstn/

Digital innovation in universities: a catalyst for progress on the SDGs in Africa

The digital transformation has been under way in Africa for several decades, and is of utmost importance to the pursuit of global objectives such as peace, health, education, ending hunger and poverty and ensuring fair access to resources. The adoption of the Sustainable Development Goals (SDGs) served to explicitly define the role of education, innovation and partnerships in the realisation of these goals, and three of them in particular:

- SDG 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all;
- SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation;
- SDG 17: Strengthen the means of implementation and revitalise the Global Partnership for Sustainable Development.

Research and higher education in Africa are closely entwined with these efforts, producing knowledge, skills and innovations to further sustainable development on the continent. These efforts are backed up with quality assurance measures (accreditation of programmes and institutions), investments in progressively improving technical capabilities (data servers and computing capacities), the creation of incubators to promote entrepreneurship and innovation, new African centres of excellence, more funding for research (kick-starter funding and bursary programmes), and more cooperation agreements with international research institutions. Nevertheless, the digital transformation of universities is still being held back by some of the challenges listed in the texts of these SDGs.

Access to digital tools and the internet is essential, but not yet equitable

All over the world, the Covid-19 pandemic further increased our dependency on digital tools in order to ensure the continuity of university education. The digitalisation of higher education is already a reality in a dozen or so universities in West Africa: open and distance learning institutes (IFOAD), virtual universities (Senegal, Nigeria, Ivory Coast, Chad, Burkina Faso). The Covid pandemic provided an opportunity to test such initiatives on a grand scale. Major inequalities among users soon became apparent, in an age when internet access in no longer a luxury but a fundamental necessity. Indeed, the cost and quality of internet connections proved to be important factors in determining the inclusion of low-income groups (including students) and facilitating the access of women to education.

The need for large-scale investment in African digital infrastructure

The gathering, dissemination and utilisation of research data require sizeable, costly digital infrastructure which represents a budgetary challenge for most African universities. For example, the cost of a recent supercomputer project in Senegal (15 million Euros) far outstripped the annual budget of the country's virtual university for 2020 (in the

region of 3 million Euros). We now need to see massive, widespread investment by governments in digital infrastructure and services, in order to expand the access of university communities to digital services and boost their competitiveness on the international scene. The introduction or reinforcement of digital investment strategies (by sovereign funds, regional forces or public-private partnerships) can help to improve the technical facilities of universities, and also to ensure that students are better equipped as soon as they begin their studies. For example, the "one student, one computer" programme (performance contract, World Bank) aimed to reach 20,000 Senegalese students in 2016, and a similar initiative was launched in Burkina Faso in 2020. The development of national cloud capabilities (such as Marwan in Morocco and CHPC in South Africa) and comparable regional initiatives (such as the Eumed Grid) should also help to reduce dependency on cloud services based in the Global North, securing data closer to home and establishing autonomously governed data centres. National and regional digital networks for research and education (NREN, RREN) work to ensure universal access to digital services for the entire higher education community. The Wacren initiative, devoted to supplying infrastructure and services to the research and education community in West and Central Africa, is a good example of such initiatives in action, as is the IRD's collaboration on the Africa Digital Campus project (https://direcct.eu/projets/africa-digital-campus/). The next step now is to find a viable economic model to cover the cost of acquiring and maintaining the necessary infrastructure.

A multi-actor partnership for closer alignment of programme goals and societal needs

Building bridges between the world of research and higher education and socioeconomic partners is essential to the development of scientific activities capable of delivering solutions and innovations. Digital tools and the transformations they engender must be put to good use, helping to transfer the benefits of university teaching and research to society at large while, at the same time, ensuring that societal problems are firmly on the agenda of academics. Some countries have established incubators or university-industry crossover initiatives, but they do not entirely satisfy this need. The difficulty lies in updating university programmes to keep pace with the ever-evolving needs of the industrial sectors in question. A delicate balance must be struck between fundamental scientific and technical content and the agility required to satisfy the demand for new skills. Short courses of study and doctoral programmes modelled on the CIFRE scheme (industrial partnerships for training through research) are avenues worth exploring, building on the co-construction of research programmes dedicated to rising to the challenges of sustainable development in Africa.

Open science, a catalyst for the SDGs

Digital technologies have become indispensable to research, as much for the purpose of generating new knowledge as for ensuring that this academic output is disseminated as

broadly as possible, and made widely accessible (publications, data, source code etc.). Specific skills are required to effectively disseminate and use this content, and that implies training academic actors in the complexities of digital technologies and their uses. At the same time, the omnipresence of digital tools in scientific research brings to light the persistent inequalities of access to knowledge and the means of its production. By raising awareness of and engagement with the practices of open science, not least the equitable, reliable and ethical dissemination of research results, all while respecting regulations ensuring the protection of personal and sensitive data, African universities and their international partners are clearly aligned with the SDGs.

Towards a more responsible digital world

The relationship between digital technology and environmental challenges is an issue of global importance, and African universities have a duty to address the issue head on, educating teachers, researchers, students and societal partners. Sustainability, responsibility and frugality must be integrated into every aspect of the digital transformation currently in progress in African universities.

KEY POINTS

Digital technologies will be indispensable to the attainment of the SDGs, and collaboration at the sub-regional and international levels will be of the utmost importance in ensuring that research and education have a positive impact on people's lives. Africa's digital transformation is well under way, but more effort is needed from the continent's governments to rise to the various challenges it presents (accessibility, security, data sovereignty etc.). Its impact on the SDGs (climate, health, agriculture, teaching) has the potential to be significant, if the responsible use of digital resources is fully understood and effectively managed by territorial authorities, civil society, the private sector and citizens at large. Hence the importance of quality education in digital science and technology. Research in this field could have a positive impact for many other sectors affected by the SDGs.

How can we amplify and promote the impact of scientific research on society?

Thomas Delahais & Agathe Devaux-Spatarakis,
Quadrant Conseil, Paris, France

Background

In the current context of multiple, overlapping crises, the complex relationship between science and society is evident in the inability of scientists to bring their authority to bear on key decisions (the climate crisis), the creeping mistrust of scientific discourse (the Covid crisis) and new demands from politicians and international organisations looking to research to demonstrate the efficacy of their actions. Nowadays, many researchers and research institutions are keen to reinforce the positive societal impact of their work. Against this backdrop, the IRD is working to develop and implement impact assessment methodologies encompassing all of our work, as well as pursuing a more functional reflection on the implications of impact culture, for our research activities but also for our institution and its processes more generally.

Contact
tdelahais@quadrant-conseil.fr
adevaux@quadrant-conseil.fr

Further reading

Delahais T. & Devaux-Spatarakis A., 2022 – Qu'attendre de la recherche pour éclairer l'action publique ? AFD, Research Papers No. 229. https://www.cairn.info/qu-attendre-de-la-recherche-pour-eclairer-l-action--1000000148971-page-1.htm.

Agreeing upon a definition

Despite being an omnipresent feature of political discourse, the notion of impact remains somewhat ambiguous for researchers, for whom it is often assimilated with impact in the academic sphere (measured in terms of citations, references, organisational positioning, invitations to conferences etc.). Nevertheless, impact also features prominently in the debate over the utility/instrumentalisation of science, particularly with regard to the value of usefulness as an evaluation criterion. The question is bound to be controversial, as certain types of research (particularly fundamental and conceptual work) do not (and are not intended to have) any direction connection to society at large. In order to tackle these ambiguities, we propose the following definitions:

"Research impact" encompasses all of the potential consequences of research interventions, individual or collective, whether those consequences are intentional or unintentional, and whether they are desirable or undesirable. Research activities may have consequences which arise from their processes or their outputs. These consequences may be direct or indirect, and occur within different time frames.

In the context of a research institution, an "impact culture" is a collective manner of thinking and acting, taking the societal consequences of research into consideration in everything the institution does. This results in an environment where the positive societal consequences of research are championed. It requires: 1) identifying strategies and opportunities to enhance the potential impact of research interventions, during the design phase but also during their deployment; 2) actively seeking out empirical evidence of this impact; 3) adopting processes of reflexive analysis and structured learning to capitalise on this information; and 4) supporting experimentation and innovation so that, in the long term, the positive consequences of interventions are enhanced and any negative consequences attenuated.

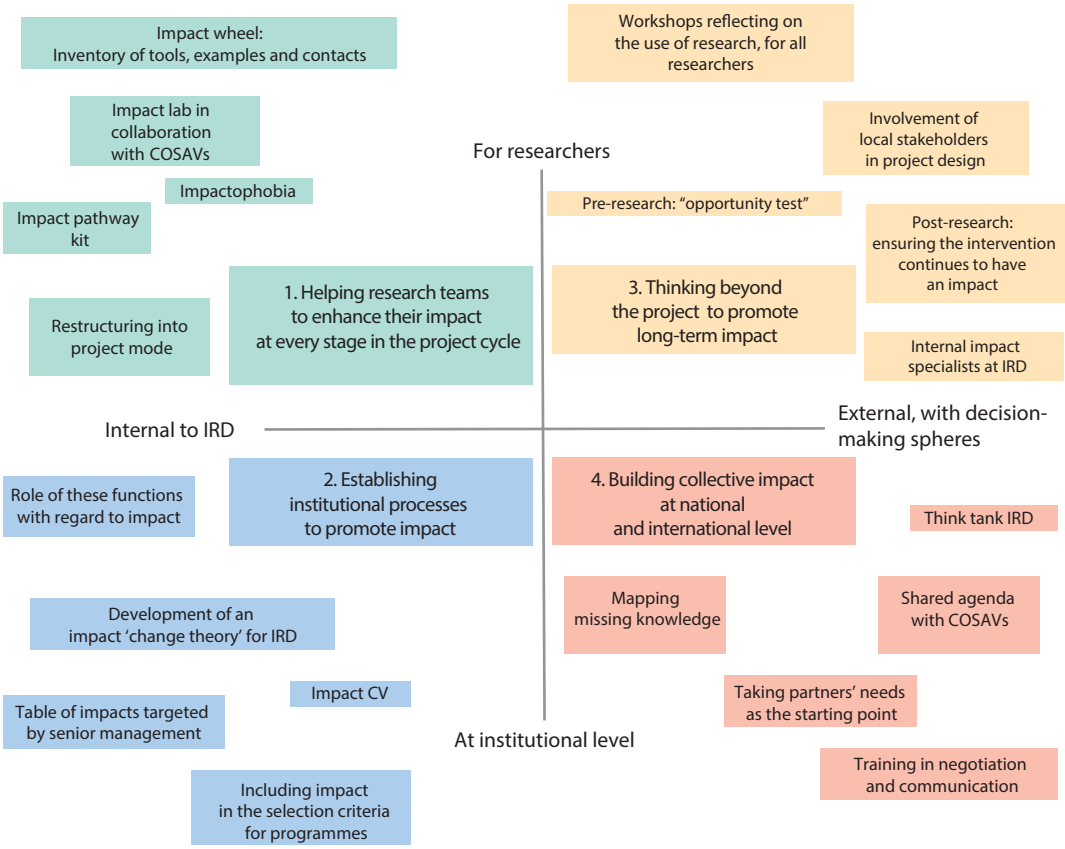
Proposing strategic guidance to enhance the impact of IRD research activities

Many of the research activities conducted at the IRD have positive practical consequences for society, actively pursued by the research personnel. A series of interviews with these researchers, along with two workshops organised with the climate knowledge community, have enabled us to identify a variety of strategies and impact pathways which could profitably be emulated elsewhere in the organisation. Nevertheless, research personnel keen to enhance their impact often find themselves working in isolation, unable to adopt systematic approaches and unaware of existing tools, even those developed in-house. Moreover, the institutional framework does not always facilitate their initiatives. Our goal is therefore to put forward strategic guidance conducive to progress in this area. Our approach was structured into two main areas. The first focused on key actors: Researcher and research teams, on the one hand, and the Institute, on the other. The second concerned the direction of the proposed changes: inward or outward-facing.

This analytical exercise yielded four prospective scenarios:

- helping research teams to enhance the impact of their work throughout the entire project life cycle, by means of coordinated support and training initiatives;
- implementing institutional processes conducive to greater impact, particularly within the different IRD divisions;
- strengthening the upstream and downstream phases of projects to encourage long term impact;
- building collective impact at global level, making use of the knowledge generated by the IRD.

These four options are not mutually exclusive, but are nonetheless discrete and distinctive, each requiring significant choices



Matrix showing our strategic propositions for enhancing the impact of IRD research activities.

and the allocation of sufficient resources. In this respect, they constitute potential source material for a future strategy which could combine certain features of each of these four options.

Prioritising support for research teams

We used two methods, one collective (a workshop) and the other individual (questionnaires), to take the pulse of the group charged with following up this mission, comprising research personnel and technical engineers, in order to discuss the proposed scenarios and identify the most desirable. Each scenario contained several concrete proposals to be implemented over the coming years. During this period of discussion and consultation, several proposals emerged as frontrunners. First was the need to involve local stakeholders in project building, directly echoing the Institute's equitable partnership model. The creation of an "impact lab" or comparable structure also appears to be essential, in order to accelerate the adoption of impact as a key criterion in the design and execution of research projects. Accessible on a voluntary basis, this structure would serve to pool existing resources (approaches, tools, experiences, contacts) as well as providing solutions for the co-construction of projects with local stakeholders, and increasing the availability and visibility of feedback pertaining to the impact of projects. Cross-cutting by nature, an impact lab could also be used to drive discussions about impact within IRD and beyond (presentations and debates on methodological issues, workshops on the use of research etc.).

KEY POINTS

A culture of impact cannot be imposed from on high, but it can be supported with the necessary resources: boosting capabilities, providing essential methods and tools, developing an organisational culture and putting in place institutional processes. In order to be effective, these resources must be utilised simultaneously. A useful starting point is to support staff already engaged in impactful research, providing the tools they need and taking inspiration, wherever possible, from existing internal examples and processes. Thereafter, it would be profitable to pursue more structural changes conducive to a gradual shift in the make-up of the IRD, establishing a framework more conducive to impact.

Towards a didactics of sustainability

Jean-Marc Lange,
Department of Education, Université de Montpellier, France

Background

Urgent changes are required to school curricula in order to tackle the crisis endemic to modern education, which continues to struggle with a lack of meaning and clear objectives. In line with SDG 4 "Quality education" (and particularly Target 4.7: "ensure that all learners acquire the knowledge and skills needed to promote sustainable development") sustainability science is an emerging academic movement which asks questions of the prevailing teaching methods[1] of existing academic disciplines, questioning and updating their content and methods in a timely process of academic evolution. Nevertheless, much as it represents an opportunity for renewal and a newfound coherency in academic disciplines and their didactic traditions, a balance must be struck between teaching the basics and integrating new forms of knowledge.

Contact
jean-marc.lange@umontpellier.fr

Further reading

Curnier D., 2021 – *Vers une école éco-logique*. Bordeaux, Éditions Le bord de l'eau.

Rising to the challenges of the age

The age in which we live has come to be defined by a series of crisis with dramatic effects for schools on multiple levels: geophysical (climate change), biological (the collapse of biodiversity) and social (social media and their uses). This state of affairs - which some describe in terms of "civilisational" crises, while others prefer the term "Anthropocene" - has plunged us, as a species, into a collective state of epistemological, social and societal uncertainty. Our schools are facing unprecedented challenges, accused of being the source of the problem (on account of being out of touch with the world) while simultaneously being expected to find the solution. As the UN made clear by unanimous vote in 2015, education (SDG 4) has the potential to act as a catalyst for all sixteen of the other Sustainable Development Goals. All of which naturally raises questions about the purpose of schools: should they be focused on improvement, attenuation, adaptation or societal transformation? For Daniel Curnier, author of *In Defense of the Eco-Logical School* (2021, Editions Le Bord de l'Eau), neglecting the transformative power of education is tantamount to conceding defeat to a "barbarous future," whereas the ambition of an "eco-logical" school should be to champion a humanist, emancipatory vision of that future. What, then, will be the educational strategies of the future? And the content to be taught?

"Educations in…" (sustainable development, health etc.) constitute a tentative institutional response to the international and societal demand for more global solutions to the challenges facing our modern world. However, too often scattered across the school curriculum and limited to behaviourist approaches (for example, learning environmentally-friendly practices), many researchers and practitioners still view these methods as somewhat moralistic and values-oriented, overlooking the importance of their content, i.e. the knowledge they convey, and its political dimension. By way of an example, food production and food itself cannot be boiled down to a simple transposition of agronomic and dietary sciences; they also raise questions of social and geographical inequalities, encapsulated in the concept of "food landscapes." By declining to acknowledge the political dimension of these cross-disciplinary educational initiatives, perhaps out of loyalty to the myth of epistemological and republican neutrality, some researchers and practitioners fall into the sort of anti-political stance defined by Melki Slimani (*Vers une éducation au politique à travers les questions environnementales*, 2021, ISTE éditions): this is not akin to political neutrality, which would be truly apolitical, but instead a position which voluntarily neglects the political dimension of the content studied. Adherents of this posture of pseudo-neutrality find themselves implicitly or explicitly at the mercy of economic lobbies and political programmes in disguise. In order to avoid such pitfalls and missteps, a number of researchers working in the field of education have firmly aligned their work with a commitment to political education in the sense of the *polis*, the public sphere, ensuring

1 • Research and practical fields which seek to build bridges between explanatory sciences and the appropriation of their results by various audiences.

that their educational proposals are consistent and clear about their objectives (see Barthes, A., 2023 – 'Sustainability sciences and education' in: *Sustainability Science*, Vol. 2, Marseille, IRD Éditions: 140-143).

Didactics and course content

In this context, what is to be done with school subjects and their associated teaching practices? The subjects taught in schools are by no means etched in stone and stuck in time: they have experienced their own social and historical evolutions, as studied by historians of education. Didactics, the study of teaching methods, emerged from two trends which converged in the 1970s and 1980s. One of these trends was driven by university academics specialising in mathematics and the natural sciences who began to question the dominant psycho-pedagogical approaches, preferring to examine learning with specific reference to the content being taught. The second was led by teachers looking for innovative methods. These two forces met in the institutional sphere, on curriculum planning committees and at France's National Institute for Educational Research, leading to the emergence of a new research field with both theoretical and practical implications, whose principal tools are the history of science and their associated epistemologies. The aim of didactics is to better understand learning difficulties and the dissemination of academic knowledge in society. Teaching methods thus form a bridge between the originators of knowledge and the appropriation of that knowledge by different groups, including school pupils. This is certainly true of the work of Jean-Louis Martinand, starting with his foundational 1986 text *Transformer la Matière* (Editions Peter Lang).

Towards a didactics of sustainability

In my view, we still need much greater clarity of vision regarding the fundamental question of the "correspondence," as Martinand would have it, between school subjects, their teaching methods and contents, and the evolution of related academic disciplines. A case in point is the increasing prominence gained by sustainability science since the 2010s. The IRD has made it an epistemological priority, marking a shift of perspective in the relationship between science and society (see Dangles O. & Fréour C., 2022 – 'Sustainability science: finding sustainable solutions within planetary boundaries.' in: *Sustainability Science*, Marseille, IRD Editions: 16-19; Dangles O. & Sabrié M.-L., 2023 – 'Introduction' in: *Sustainability Science*, Vol. 2, Marseille, IRD Éditions: 12-13). The IRD's tripartite mantra of "understand, co-construct, transform" resonates clearly with the "knowledge, understanding, action" triptych often associated with sustainable development and its transformative potential. Sustainability science offers opportunities to overhaul old educational models, moving beyond dominant paradigms obsessed with the accumulation of knowledge (Barthes A., 2023 – 'Sustainability sciences and education.' in: *Sustainability Science*, Vol. 2, Marseille, IRD Éditions: 140-143).
But what about teaching methods? Sustainability science is partly defined by the research approaches it champions, with a particular focus on interdisciplinarity (dialogue between natural sciences and human and social sciences) and transdisciplinarity

(receptiveness to local and traditional forms of knowledge). It favours integrative epistemological approaches (One Health, Eco Health etc.), which is to say approaches which seek to unite environmental issues with the social and developmental issues facing a territory. By the same token, education in sustainable development tends to favour inter- and transdisciplinary approaches which focus on local sustainability challenges by means of investigative research, making school work a participatory force. This educational philosophy also affords special importance to forward-looking approaches, encouraging learners to imagine potential future developments. Finally, territorial rootedness allows for partnerships with local stakeholders, thus permitting the inclusion of traditional knowledge and experience conducive to transdisciplinarity. Sustainability science and its didactics - devoted to building bridges between disciplines, in contrast with our current, fragmented curricula - are capable of bringing greater cohesion and purpose to educational pathways, without seeking to radically redefine existing school subjects. This didactic philosophy has the potential to reinvigorate the content and meaning of teaching programmes, in pursuit of a humanist, emancipatory, transformative and integrative education on environmental and development issues (including health) which remains firmly rooted in territorial realities. This could lay the foundations for a new way of looking at the world. We must now define and experiment with a few flagship themes, identify the fundamental, structural knowledge they entail, establish their feasibility and acceptability to educators, and convince institutional decision-makers of the pertinence of this approach to making school curricula more coherent.

KEY POINTS

Teaching methods, or didactics, form a bridge between the originators of academic and non-academic knowledge and the appropriation of that knowledge by different groups, including school pupils. They also seek to lay bare the difficulties standing in the way of learning and knowledge dissemination, and to propose timely forms of correspondence between the academic world, the social world and the world of education and training. Their fundamentally reflexive, practical approaches are backed up by the epistemological heritage of the sciences they invoke. A new didactics of sustainability would serve to make existing school subjects more up-to-date, more coherent, more meaningful and more purposeful, bringing greater clarity to teaching methods which are often too fragmented and technocratic. This would serve to enhance the contribution of education, both in schools and elsewhere, to the urgent ecological transformation.

Knowledge brokering: rising to the challenges of sustainability science

Valéry Ridde & Tony Zitty,
IRD, UMR Ceped, Paris, France

Background

An incredible quantity of research results on a dizzying array of topics is not only available, but constantly growing. The lack of action witnessed in certain domains (climate change, inequality etc.), as well as the wealth of policies and actions launched without proper consideration for pertinent data, demonstrate the difficulties of mobilising science to inform decisions. One promising solution for bridging the gap between the research community and the people in positions to take decisions is the concept of knowledge brokering. Whether piloted by an individual or an organisation, knowledge brokering works to promote science-based decision-making, taking contextual circumstances and power balances into consideration, without grand illusions but also without naiveté.

Contact
valery.ridde@ird.fr

Further reading

Dagenais C. *et al.*, 2021 – Collaborative Research and Knowledge Translation on Road Crashes in Burkina Faso: The Police Perspective 18 Months On. *Health Research Policy and Systems*, 19 (1): 3.

https://catalogue.edulib.org/fr/series/le-transfert-de-connaissances; https://audioblog.arteradio.com/blog/184108/podcast/203684/tony-part-i-qu-est-ce-que-le-transfert-de-connaissances

Ridde V. *et al.*, 2013 – Une synthèse exploratoire du courtage en connaissance en santé publique. *Santé Publique*, 25 (2): 137-145.

Two separate worlds

The Covid-19 pandemic illustrated just how difficult it is to ensure that decisions are based on science. When governments decided to impose lockdown measures, they rarely consulted public health experts or historians of past epidemics. In areas such as climate change, health inequality and the inability of the poorest members of society to access healthcare, solutions have actually been available for many years: the lack of action and clear decisions demonstrate the limitations of scientific mobilisation. The scientific community is often denigrated, sometimes in very stereotypical terms. Scientists and decision-makers live in different worlds, worlds which are often too inward-looking, governed by rules and standards which are too different to allow for fruitful exchanges and discussions. Research teams are judged in the long term, based on the grants they win and the publications they produce, whereas politicians are often judged on their ability to make people-pleasing decisions within the short time frame of an election cycle. While members of the scientific community are sometimes criticised for failing to understand the workings of power, those in a position to make political and technical decisions are regarded as lacking in the scientific literacy required to gauge the quality of studies which might be of use to them - if, indeed, they are even aware of such studies.

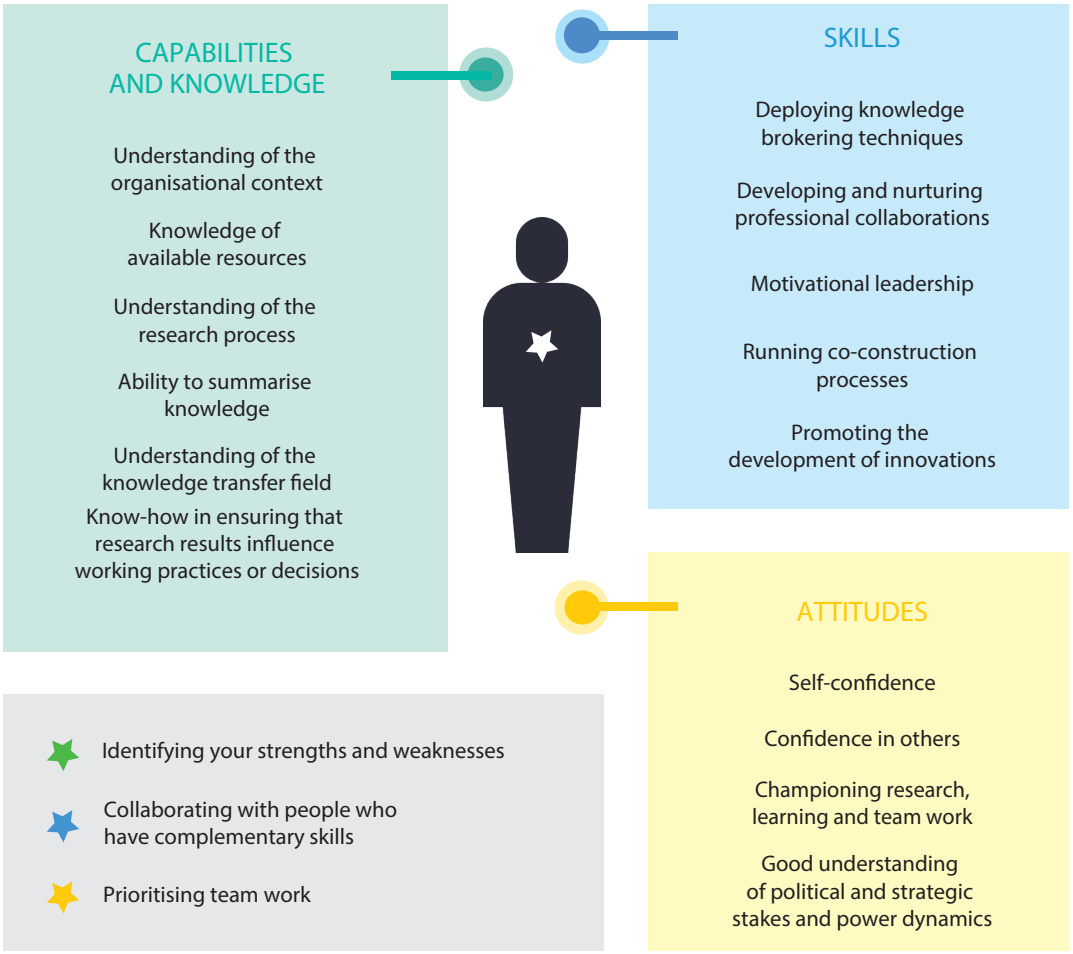
From mobilisation to scientific mediation

If the prevailing time frames, knowledge, skills, interests, capabilities, norms and contexts of the academic and political spheres are so different and so difficult to change, then why not turn to a person or organisation capable of acting as an interface? Cultural mediation in museums, social mediation in neighbourhoods, interpersonal mediation for families - all of these are well-established. Nonetheless, the idea of an intermediary presence between science and the organisations responsible for establishing and implementing public policy is a relatively new one. Not all forms of research (especially in fundamental sciences) necessarily lead to decisions liable to change the way we live in the short term. However, if we accept that the knowledge generated by research can usefully inform decision-making, particularly in fields such as health, education, the fight against deforestation, habitat protection and the conservation of coral reefs - all matters of sustainable development - then there is certainly an opportunity to make use of knowledge brokering. The person or organisation acting as broker must seek to understand the needs of decision-makers, support research teams as they adapt their works for the purposes of decision-making, conduct systematic surveys of the current state of international knowledge on the subject, and present these findings in accessible terms conducive to action. Brokers need the requisite interpersonal qualities to fulfil this intermediary role (humility, motivation, dynamism, leadership), as well as the technical capacities needed to understand the scientific sphere (its methods and workings) and the mechanics of decision-making (strategic and political considerations, opportunities for action, need for

adaptation). Moreover, experiments with brokering in the development sphere are rare and will require further study in order to identify the conditions required for them to succeed. What we need is a science of how best to use science.

The challenges of knowledge brokering in Burkina Faso and the Île-de-France

Two examples can help to illustrate the current state of knowledge brokering. During a



Skills, capacities and attitudes for knowledge brokering
(https://catalogue.edulib.org/fr/series/le-transfert-de-connaissances).

five-year interventional research programme focusing on public healthcare in the Kaya district of Burkina Faso, the participants experimented with a knowledge brokering initiative. A person with a master's degree in sociology was recruited, trained and tasked with of creating opportunities for the research produced by the programme (on health insurance, malaria, dengue fever etc.) to be of use to local and national decision-makers. They produced summaries of new and existing knowledge, organised deliberative workshops, produced guidance notes and helped researchers to make their results more accessible and pertinent. The lessons learned from this experience demonstrate the importance of taking proper consideration of power dynamics (medical hierarchies, centre/periphery and North/South relations) and the context in which decisions are taken, in order to adapt knowledge brokering activities and functions accordingly.

Another example comes from the Île-de-France region of France, where insufficient use is made of available scientific data on social healthcare inequalities (SHIs) when designing solutions. With this goal in mind, an 18-months research-action project (Courtiss) launched in April 2022 is working to promote knowledge brokering as a means of reducing SHIs, running in partnership with the regional public health agency. The programme is seeking to improve the precision of the agency's SHI actions, using scientific knowledge to inform decision-making. In addition to the relatively short 18-month window afforded to a research-action programme, the fact that professionals often lack the time needed to take part in brokering activities remains a challenge, and highlights the need for more institutional support for knowledge brokering.

KEY POINTS

Knowledge brokering would appear to be indispensable for the realisation of social and political changes which are, at least in part, based on science. But brokering must form part of a clearly defined knowledge transfer plan, backed up with sufficient means and skilled personnel. Knowledge brokering is a promising strategy for encouraging the use of research results to inform decision-making. It is a relatively new function and a profession in need of further development, so that the scientific and political spheres can collectively contribute to informed decision-making in the interests of sustainable development. Like research, scientific mediation is a profession in its own right - a profession in its infancy, which needs to be supported and championed. This is one of the key proposals made by the Global Evidence Commission in a report published in January 2022.

Sustainability science in Horizon Europe collaborative projects

Alice Comte, Stéphanie Juban, Laura Leblanc & Colin Volle,
Europe Unit, IRD, Marseille, France

Background

Horizon Europe is the European Union's framework programme for research and innovation for the period 2021-2027. Responding to global challenges, including the 17 Sustainable Development Goals (SDGs) is one of the principal objectives of this programme. With an allocated budget of 95.5 billion Euros, Horizon Europe is founded upon four pillars: 1) Excellent Science; 2) Global Challenges and European Industrial Competitiveness; 3) Innovative Europe; and 4) a cross-cutting pillar focused on expanding involvement and reinforcing Europe's research sphere. Pillar 2, which hosts the majority of calls for collaborative projects, offers fertile ground for the development of sustainability science.

Contact
sae@ird.fr

Further reading
www.horizon-europe.gouv.fr

The impact philosophy of Horizon Europe.

The evolving understanding of "impact" in European research programmes

In 2017, Carlos Moedas, then European Commissioner for Research, Innovation and Science, described the question of impact in the forthcoming Horizon Europe programme in the following terms: "For political reasons, impact will be - along with excellence and openness - one of the three fundamental values of the next framework programme for research." The Horizon 2020 programme (2014-2020) already represented a major development in the history of European research programmes on account of its enhanced focus on impact, and particularly societal impact. Indeed, Horizon 2020 was designed to boost the valued added and impact of the EU by focusing on objectives and activities which could not be effectively handled by member states acting individually. This shift in approach was given concrete form in a strategic plan followed by a series of Key Strategic Orientations, further broken down into Impact Areas and Expected Impacts. These expected impacts corresponded to the desired long term effects of research and innovation for society, the economy and science at large, without specifying how they were to be achieved.

Impact in the calls for proposals in Horizon Europe's second pillar

Pillar 2 of the Horizon Europe programme is broken down into six thematic clusters, aligned with European policy priorities and the SDGs: 1) health; 2) culture, creativity and inclusive society; 3) civil security for society; 4) digital, industry and space; 5) climate, energy and mobility; 6) food, bioeconomy, natural resources, agriculture and environment. Each cluster is designed to span multiple strategic orientations, impact areas and expected impacts.

Calls for proposals thus follow a hierarchy of priorities where expected impacts are top of the pile. All projects are invited to submit an impact pathway which sets out the different routes and leverage effects which will enable them to achieve their stated results, in conjunction with communication, dissemination and operationalisation efforts which will contribute to the realisation of long term impacts. On a more general level, one of the major innovations of Horizon Europe is the introduction of *Key Impacts Pathways,* a tool allowing the Commission to measure the impact of the Horizon Europe programme as a whole, on the basis of 9 indicators.

Interdisciplinarity: a prerequisite for European collaborative projects

Interdisciplinarity is a core requirement for collaborative projects under Pillar 2 of Horizon Europe, assessed under the banner of the "excellence" criterion, one of the three main criteria used to evaluate collaborative project proposals (the others being impact and implementation). Project teams must thus demonstrate the complementarity of the different domains or fields of expertise on which they draw. If, however, a proposal does not include an interdisciplinary dimension, then a clear justification for this choice must be presented. Moreover, the active involvement of human and social sciences is essential and must be set out in detail, if the call for proposals demands it.

Co-constructing multi-actor European collaborative projects

In addition to interdisciplinarity, Pillar 2 of the research framework programme also seeks to encourage intersectoral collaborative projects which promote a multi-actor approach. Consortia are encouraged to guarantee the involvement of citizens and civil society partners, in order to more effectively take their needs into consideration. For Horizon 2020, the Commission adopted the concept of quadruple-helix collaborations, viewing research as a collective undertaking pursued by four branches that must be encouraged to work together: industry, government, research institutes, and the public. Finally, collaborative projects place greater emphasis on practices such as co-construction, co-creation, multi-actor approaches and co-design, requiring the integration and coordination of multiple stakeholders.
The working programme for Cluster 6 offers a definition of a multi-actor approach as "a form of responsible research and innovation, aims to make the research and innovation process and its outcomes more reliable, demand-driven, shared and relevant to society." Collaborative projects adopting such approaches should be capable of developing innovative solutions in response to real needs.

Transformational collaborative projects at European level

The production of knowledge and innovative solutions by collaborative projects must also satisfy the demands of the global/local/cross-cutting triptych. This approach seeks to ensure that the use of new knowledge by a project operates on different levels without engendering unintentional negative consequences for its environment. Project proposals must thus include a results and knowledge matrix designed to forestall risks and maximise

positive impacts. Under the aegis of the joint strategy for the promotion of R&I, the Commission encourages projects to incorporate activities such as communication and the dissemination and operationalisation of results. In order to support projects keen to go beyond simply fulfilling their obligations when it comes to operationalising results, the Commission has also launched the *Horizon Results Booster* initiative, a new raft of services aiming to maximise the impact of research projects funded by FP7, Horizon 2020 and Horizon Europe.

Projects with high impact potential funded by Horizon Europe

The IRD is currently coordinating the Quali-Dec project (Horizon 2020/2020-2025), conducted by a multidisciplinary international team comprising healthcare practitioners and researchers in medicine and social sciences from nine different countries. The team is led by Alexandre Dumont, gynaecologist/obstetrician and IRD Research Director (UMR Ceped). The results of the project inspired a draft bill submitted to the Argentinian parliament on 7 November 2023 proposing the foundation of a "National Programme for the Appropriate Use of Caesarean Section" (PNUAC). The purpose of the bill is to reduce the number of medically unjustified C-sections performed in the country.

Meanwhile, the Mosaic project (Horizon Europe/2023-2027), led by Emmanuel Roux (UMR Espace-Dev), is working to improve the health of local cross-border populations in East Africa (Kenya) and the Amazon (Brazil) by co-producing knowledge and data on the environment, environmental changes and their health impacts. This project has adopted an intersectoral approach focused on co-construction with decision-making bodies and local communities, seeking to build solutions based on both scientific knowledge and community expertise, ensuring that they are both acceptable and sustainable.

KEY POINTS

Horizon 2020 and Horizon Europe have helped to reinforce the impact of research closely connected with sustainability science, promoting a 'problem-centric' approach. The emphasis placed on impact is particularly evident in Pillar 2 of Horizon Europe, the section which contains the most calls for collaborative research proposals, structured into clusters corresponding to the programme's strategic objectives and expected fields of impact. The prioritisation of interdisciplinarity, co-construction and the transformative potential of collaborative projects is also entirely in keeping with the philosophy of sustainability science.

Transformative territorial science: the example of the "Zone Atelier" network

Olivier Ragueneau,
CNRS, UMR Lemar, Plouzané, France
Vanessa Lea,
CNRS, UMR Traces, Toulouse, France

Background

In a world grappling with what Nancy Fraser calls the "non-choice" between adaptation to globalisation and the socioenvironmental damage it wreaks and the temptation to look inwards gaining ground in many parts of the world (not least in the guise of growing populism), transformation should be at the forefront of our minds. Given its association with ideas of development and progress, science can ill afford to shirk its responsibility to find ways out of this unsustainable state of affairs, which is threatening to make our planet uninhabitable. But how do we actually put these transformations into practice in our territories?

Contact
olivier.ragueneau@univ-brest.fr

Further reading

https://www.inee.cnrs.fr/fr/zones-ateliers

Oreskes N. et Conway E. M., 2014 – *Les marchands de doute*. Paris, Le Pommier.

Paasche Ö. et Österblom H., 2019 – Unsustainable science. *One Earth*, 1: 39-42.

Polanyi K., 2009 [1944] – *La grande transformation. Aux origines politiques et économiques de notre temps*. Paris, Gallimard.

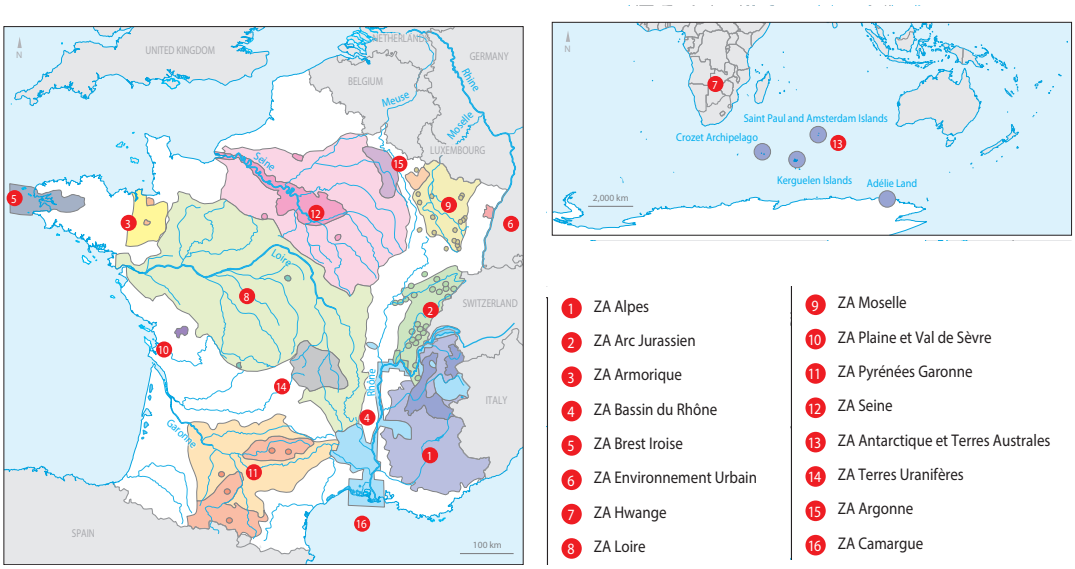
Schneidewind U. *et al.*, 2016 – *Handbook on sustainability transition and sustainable peace*: 123-136.

The 'transformative science' dimension of sustainability science

Sustainability science first emerged as a concept in the early 2000s, and is supposed to generate knowledge for the advancement of sustainable development. But development, as per the current definition framed in terms of growth and GDP, is by no means sustainable: neither socially nor environmentally. Even when growth is dressed up as being "green" or "blue," it is leading us down an unsustainable path. Adaptation will obviously be necessary over the coming decade, in order to soften the blow of the shocks yet to come, but adaptation alone will not suffice. A new "great transformation" will be absolutely necessary to limit the scale and frequency of the social and environmental disasters which are threatening the very liveability of our planet. One branch of sustainability science has taken transformation to heart, championing joint research with territorial actors, training and institutional innovation. The idea of "transformative science" represents a major turning point in the history of science, and raises many questions as to how science and society, and society and politics, can interface effectively. The issue of scientists' individual positioning is of clear significance. The aim of this short contribution is to explain how a research infrastructure - namely the Zone Atelier Network (RZA, CNRS - Ecology & Environment) - is positioning itself within this field, taking concrete action to bring about transformation on multiple levels.

The Zone Atelier network as a field study in the philosophy and action of transformation

A Zone Atelier (French for "workshop zone," often abbreviated to ZA) is a co-research initiative involving researchers and territorial actors, who join forces to better understand - from a territorially rooted and long-term perspective - the workings and evolution of socio-ecosystems, and thus to help these territories with their sustainable transformation. There are currently fifteen such zones. They are used to develop and test new approaches designed to improve and facilitate interdisciplinary research, particularly research combining input from earth and life science and human and social sciences, not to forget engineering sciences. They also serve to develop and test methods for facilitating joint research involving higher education and research professionals working in partnership with different types of actors and territorial stakeholders (managers, local authorities, SMEs, non-profit organisations, other sectors of education). The central hypothesis underpinning ZA networks is that the co-production of knowledge is a necessary condition (albeit not a sufficient condition) for improving and transforming public policy on matters of sustainability. To test this hypothesis, ZA networks set up experiments enabling territorial stakeholders and academic researchers to collectively re-engage with the major issues facing the territory, to explore potential solutions and to make potentially transformative proposals while working to strengthen capacities and individual and social action capabilities. The goal is to work with actors to galvanise changes in praxis and observe the medium and long-term



Map of the 16 ZA areas, spread across mainland France as well as the sub-Antarctic islands and Zimbabwe. A ZA is always structured around a particular functional unit, such as a major river, mountain range, agricultural plain or city. Three new ZA projects are currently in the construction phase in Camargue, French Guiana and French Polynesia

(Courtesy of Réseau des zones ateliers/M.-N. Pons).

consequences for the environment, as well as the economic, social, political and legal ramifications. The advantage of working as part of a network is that it allows for a more systemic transformative perspective. That begins with the sharing of methodologies, working in an inter- or transdisciplinary fashion, testing the methods in cross-cutting projects involving multiple ZAs. This may also involve pooling a certain number of the services required by the scientific community (e.g. inter- or transdisciplinary methodologies) and territorial stakeholders (e.g. reinforcing capacities, decision-making etc.). Naturally, this also includes the coordination of multiple experiments conducted by the ZAs, which are always situated but which must be connected in order to foster "joined-up learning" and disseminate its benefits. This is not so much about "upscaling" as it is about learning to capitalise on the diverse array of situations which are within reach when working as part of a network, adopting comparative approaches or testing hypotheses at different points on the gradients (climate, anthropization, record of joint research etc.).

Implications for social, educational and institutional innovation

• The concept of innovation is of crucial importance to the science of transformations, and far transcends technological innovation: the latter alone will not suffice to get us out of our current predicament. Innovation is also required in the social sphere, for example through the development of third places allowing for the

encounters and interactions, shifts in perspective, decentring and relations of care required for inter- and transdisciplinary approaches to work. Innovation must also incorporate an educational dimension, not only to convey the complexities of socio-ecosystems, but also to develop different ways of approaching them. Above all, innovation must be institutional, in order to facilitate all of the necessary accompanying forms of transversality. Quite aside from the urgent need to break our institutions out of their organisational silos, the problem of working in inter and transdisciplinary mode - of such vital importance in this age of division, misinformation and fabricated ignorance - is that it takes a lot of time, a resource which is in short supply for everybody these days. But behind this "time shortage" so astutely described by sociologist Hartmut Rosa, a political dimension lurks: acceleration and its social and cultural determinants, the competition and techno-solutionism whose reach now extends to research. If research, too, falls prey to the acceleration, it becomes increasingly incapable of grasping the complexity of socio-ecosystems, the pernicious problems we must all face at both the local and the global levels. To be capable of stimulating and/or supporting genuine territorial transformations, research itself needs to be transformed; not only in terms of its practices, but also with regard to its objectives and, above all, the ways in which it is assessed and funded. This is not to say that everybody must be "forced" to take this direction, but rather that those who wish to do so should be provided with the necessary opportunities, as early as possible in their academic careers. The timing is opportune: the dilemma of the environmental footprint of research is a major incentive to take our time (in the spirit of "slow science"), to rethink both our working practices and the deeper meaning of our research work, considering what defines quality in this context of climate emergency. We all have responsibilities to take (https://labos1point5.org/les-textes-positionnement/ResponsabiliteESR#textecollectif). Time is of the essence, and the ZA network will be working hard over the coming months and years, in close collaboration with our partners, on the ground as well as at national level.

KEY POINTS

The development of transformative approaches with a systemic dimension requires a combination of actions and reflections at different levels. Joint research with territorial actors - necessary, and necessarily situated - can expand our idea of innovation to embrace social, educational and institutional dimensions. This has implications for the meaning attached to our work, and for the way that the research and education world is run - a profound overhaul which is urgently needed. The question of the role of science in society must be at the heart of this process, as well as the ways in which research is funded, conducted and evaluated.

In defence of artistic ecologies

Nathalie Blanc,
CNRS, UMR Ladyss, Centre des politiques de la Terre, Paris, France

Background

The current lifestyles of the Global North and the world's wealthy populations are no longer sustainable. They are made possible by the predatory exploitation of other people, or other countries. Our ways of living are in need of a radical, emancipatory socioecological transformation. The challenge we now face is to imagine alternative ways of living which satisfy our fundamental human needs, respect the planetary boundaries and are compatible with social and ecological (re)productivities. What can artistic practices bring to this process, and do they have potentially transformative capacities? Recent research has shown that artistic practices allow for the creation of extraordinary socioecological interactions, testing grounds for the transformations needed to reshape our ways of living. However, the obstacles to change are many and varied, including local policies, project funding structures, regulatory constraints and cultural bias.

Contact
nathalie.blanc@icloud.com

Further reading

Benish B., Blanc N., 2022 – *Art, Farming and Food for the Future: Transforming Agriculture*. London/New York, Routledge.

Blanc N., Benish B., 2016 – *Form, art, and environment: engaging in sustainability*. London/New York, Routledge.

The importance of cultural questions in the Anthropocene era

Given the urgency of the ecological challenges we face, why should we concern ourselves with cultural matters? Broadly defined, culture is the totality of practices and representations which structure the way we live in society, and how we pass those traditions on. In this sense culture corresponds to the meaning which human communities attach to themselves, the symbolic models, norms and rules which set us apart from the rest of the natural world. Culture can also be a force for division, which is precisely why it is such a complex concept. In this time of crisis, it is urgent to reconsider the cultural foundations which inform our representations of the world and which have led us, and continue to lead us, to overlook the material consequences of our actions and refuse to recognise that the materiality of our planet represents a non-negotiable limit to human imagination and development. These representations and their sensory mediations take many forms: maps, photographs, paintings, globes, signs, stories, music etc. Their very ubiquity demonstrates just how important it is to devote proper attention to the cultural dimensions of what makes our planet liveable. Since the late 1960s/early 1970s, artists affiliated with the environmental art movement have been endeavouring to do just that. Expanding artistic practices to embrace ecology also represents an invitation to consider the renewed social role of artists and their work, and the power of art to act as a catalyst for socioeconomic transformation.

An artistic project to promote a sustainable food culture

There is no shortage of examples of art projects with ecological ambitions (Blanc & Benish, 2016). A recent project entitled "Creative Europe: the Table and the Territory" included research-creations by teams of artists and scientists focusing on sustainable food. Providing sustenance is an everyday art form, one which fosters the transmission of know-how and life skills. This art is profoundly rooted in our cultures and territories, based upon techniques developed over the course of many centuries. Consider, for example, the deep-seated differences between using a fork or eating with your fingers. The culinary art has also been transformed in recent centuries, with the advent of global travel. Recipes and ingredients can now travel the world. Cooking is a symbolic art form, a blend of language, stories, aromas, textures and sounds. It is also an everyday art form traditionally associated with women, even when their role is underplayed. Ecological artists' collectives determined to bring about a more sustainable food culture are working to reinvent territories, both symbolically and technically, by forging new bonds between the urban and rural worlds, between the natural and the artificial. Furthermore, they are emphasising the connection between cooking and everyday, popular art. The "Table and Territory" project includes a case study of the urban farm in Saint-Denis, just north of Paris. Olivier Darné, an artist born and raised in the town, developed a passion for beekeeping some twenty years ago. In the early 2000s, lacking room to set up hives on his own roof, he persuaded the

city council to allow him to set some up in public places. Saint-Denis is now home to eighty hives and some six million bees, making it the biggest urban beehive in Europe. Some time later, in 2016, the Saint-Denis town council launched an urban farm competition, determined to support the continuance of urban agriculture in spite of the pollution affecting the soils. Convinced of the environmental and societal potential of this farming idea, Olivier Darné decided to submit an application on behalf of his collective, the *Parti Poétique*. That project proved built seamlessly on the collective's past work on biodiversity, establishing a circular economy with the town's newly-founded culinary academy: the fruits, vegetables and plants grown on the farm would be cooked at the academy, and the organic waste reused to provide fertiliser for the farm (Benish & Blanc, 2022). Researchers working with the artistic collective published a book gathering together testimony from local people and recipes from the past, present and future, a blend of stories and cooking tips whose launch was celebrated with a gala dinner on site.

Art as a transformative experience

On a more general level, I believe that art and cultural practices offer means of profoundly transforming our cultural views of nature, as long as these practices are represented sensitively and not regarded solely as tools for scientific or political communication. Artistic practices benefit from a certain poetic outlook, a desire to restore some of the world's magic, a mode of expression which puts our relationship with the environment back on a sensitive, indeterminate footing. The goal is to cast off the shackles of everyday routine, working with local communities to imagine connections and trajectories capable of transforming local lifestyles and habits. Creativity can also offer a new context for action, freeing up a bit of institutional breathing space. In this respect, art can be used not to create content, but context. Of course, this mode of transformation is above all interstitial, along the lines of micro-utopias (temporary manifestations of an ideal civic culture in which participants test-drive political concepts, processes and social interactions), conceived of as experiments in research-creation. This approach makes it possible to use concrete activities as a jumping off point for exploring broader issues and subjects such as subsistence in contexts which require a redefinition of collective needs.

The disruptive meeting of science and art

Artistic projects with an ecological bent are sometimes developed in parallel with scientific research. It is important to note that such research-creation projects represent not only a transformation of scientific methodologies and artistic perspectives, but also a new vision of our socio-natural world and its workings, made possible by the radical shift of approach. The freedom to apply poetic licence to the strictures of academic language also hints at the possibility of a new critical perspective on the scientific norms and objectives which are fuelling the current ecological crisis. Adopting a more poetic stance, research-creation often reveals the

emancipatory power of poetry, its capacity to slip between the cracks of discursive norms and redraw their contours, relaying flashes of reality, striving for an oneiric vision of the world around us and its norms, highlighting some of its potentially transformative properties. Such projects are capable of magnifying, transforming and shifting reality itself, or what passes for reality in a given context, making it seem monstrous or else hiding or even inhabiting it. In the odd couple formed by scientist and artist in such research-creation endeavours, the former embodies objectivity and methodological transparency, while the latter favours the ambiguities and rough edges of poetic language. Research-creation is about muddying the waters of that transparency, without forgetting the importance of having a method which stands up in real life conditions.

KEY POINTS

By facilitating the construction of projects for the environmental transition, in partnership with territorial stakeholders, while also nurturing creation and discussion of desirable futures in a manner separate but complementary to the scientific method, the arts have much to contribute to the socioecological transformation. Nevertheless, there are many obstacles impeding the use of this potential, including ignorance of the longstanding historical entanglement of art and social change, issues surrounding the funding of artistic and research-creation activities, the involvement of government bodies and the challenge of maintaining public participation over the long term, at odds with the tight time frames on which projects generally operate. In order to be effective, research-creation initiatives and territorial socioecological experiments must be regarded as long term projects, backed by a network of partners committed to the transformation and determined to make their local areas fairer, more resilient, more sustainable and better places to live.

Evaluating the sustainability of agricultural systems: the example of the Idea4 method

Frédéric Zahm [1], Sydney Girard [1], David Carayon [1], Bernard Del'homme [1], Inês Rodrigues [2], Adeline Alonso Ugaglia [3], Mohamed Gafsi [4], Clément Gestin [5], Pierre Gasselin [6], Chantal Loyce [7], Vincent Manneville [8] and Barbara Redlingshöfer [9][1]

Background

Societal demand for quality, responsible agriculture, coupled with the need to adapt to climate change, is driving more and more farmers to embark upon agroecological transitions. In order to support this necessary transition towards more sustainable practices, all stakeholders in the agricultural sphere (farmers, agricultural consultants, sectors, consumers, collectives and educators) need robust methods of evaluation capable of measuring the sustainability standards achieved by farms, while also identifying catalysts for further improvements which are suited to the production systems in place. In order to ensure that these methods are used as widely as possible, they will need to be educational, accessible, scientifically sound, field-tested and transparent, so that all stakeholders can feel confident in the validity of the results obtained. It was with these challenges in mind that the Idea4 method was developed (farm sustainability indicator - version 4)

Contact
frederic.zahm@inrae.fr

Further reading
Zahm F. *et al.*, 2024 – *La méthode Idea4*. Éducagri Editions, https://www.edued.fr/LS/IDEAV4

What methods should we use to evaluate agricultural output?

Sustainable systems of agricultural production incorporate environmental, economic and social considerations. Evaluating their sustainability, and particularly their capacity to contribute to the Sustainable Development Goals (SDGs), requires diagnostic methods compatible with the diversity of agricultural systems and outputs.

Even at individual farm level, the existing scientific literature offers more than a hundred potential methods, each with its own specificities in terms of:

- the theoretical framework used to construct the method (strong/weak sustainability; approaches based on the SDGs, definitions of sustainable systems, strong/weak engagement with agroecology, financial criteria assessed or not etc.);
- the definition of sustainability and list of societal and thematic objectives used, which will determine the scale at which the method understands the concept of sustainability;
- the purpose (advice, teaching, research, public action) of the method and the types of farms involved (general agriculture or specialist operations);
- the operation framework guiding the aggregation of criteria and the type of tools used (material and energy audits, life cycle analyses, indicators, optimisation models etc.);
- specific characteristics (forward-looking or retrospective assessment, evaluation based on pressure measurements or indicators, qualitative or quantitative analysis, dashboard or aggregated indicator, etc.);
- the nature, origin and quality of the information used to construct the method will determine the absolute or relative nature of the evaluation, and define the scope of its validity (farm types, agricultural models, legal structure of farming operations, geographical factors etc.);
- the scale (plot, farm, territory etc.) at which data is gathered.

Idea4, a method using two complementary approaches to evaluate sustainability

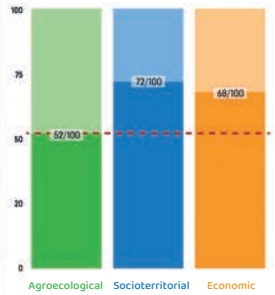
The Idea method was initially created in response to a demand from France's Department of Agriculture in the mid-1990s. The ministry wanted to equip agricultural educators with an accessible, easy-to-use tool capable of expressing the notion of sustainability in agriculture in more concrete terms (https://methode-idea.org). Based on a solid theoretical framework, and tested for eight years in a collaborative process involving over 800 farms, the Idea4 method's operational structure comprises two complementary approaches to sustainability:

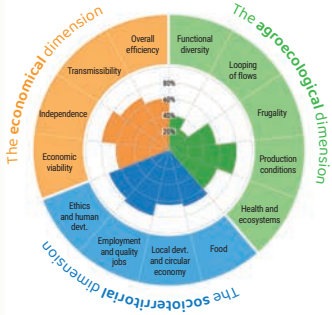
- An initial structural analysis table containing 53 agricultural indicators relating to the three pillars of sustainable agriculture (agroecology, socio-territoriality, economics), divided into

1 • [1] Inrae, UR Ettis, Cestas, France; [2] Bergerie nationale de Rambouillet, Rambouillet, France; [3] Bordeaux Sciences Agro, UMR Save, Gradignan, France; [4] Ensfea, UMR Lisst, Toulouse, France; [5] Centre écodéveloppement de Villarceaux, Chaussy, France; [6] Innovation, université de Montpellier, Cirad, Inrae, Institut Agro, Montpellier, France; [7] AgroParisTech, UMR Agronomie, Palaiseau, France; [8] Institut de l'élevage, Aubière, France; [9] Inrae, UMR Sadapt, Paris, France.

An evaluation table structured around the three dimensions of sustainable development

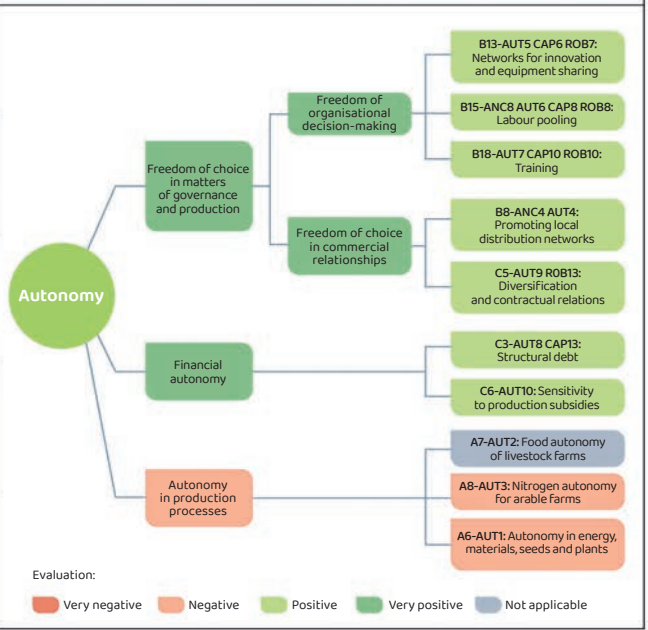
3 dimensions ...	... with 13 components	Sample results: histogram for the 3 dimensions	Sample results: radar chart for 13 components
The **agroecological** dimension	Functional diversity Looping flows of materials and energy in pursuit of autonomy Frugal use of resources Ensuring conditions conducive to production in the medium and long term Reducing impact on human health and ecosystems		
The **socioterritorial** dimension	Food Local development and the circular economy Employment and quality jobs Ethics and human development		
The **economic** dimension	Economic and financial viability Independence Transmissibility Overall efficiency		





An evaluation table structured around the five properties of sustainability

5 properties...	...structured into 15 branches	Sample results: tree diagram for 'Autonomy'
Production capacity of goods and services	Capacity for timely production of valued goods and services Capacity to generate income in the long term	
Autonomy	Freedom of choice in matters of governance and production Financial autonomy Autonomy of production processes	
Robustness	Limiting exposure to threats Reducing sensitivity Boosting capacity to adapt	
Territorial roots	Championing territorial quality Contribution to circular economy Involvement with territorial initiatives	
Overall responsibility	Social involvement and engagements Equitable sharing of resources Contribution to quality of life on the farm Reducing impact on health and ecosystems	



The two approaches to evaluating sustainability - dimensions and properties.

13 categories. The evaluation process works by calculating a score for each indicator, then aggregating the scores using a capped weighting technique. The lowest score from the three dimensions is regarded as the final sustainability score (for strong sustainability).

• A second analysis is then performed to measure this sustainability against the five properties of sustainable agricultural systems (productive capacity, autonomy, robustness, territorial connections, responsibility), with the 53 indicators split between fifteen branches. The qualitative and hierarchical aggregation process assigns a performance rating (negative, positive etc.) to each indicator, then each branch, and finally the whole farm.

An operational, educational, open access method

Idea4 can be used to evaluate the sustainability of the majority of agricultural production systems found in mainland France, and indeed in Europe. Its calculation rules and performance ratings make it possible to evaluate farms on the basis of their practices and activities, identifying pathways to greater sustainability to boost individual and collective progress in the agroecological transition. It is already widely used in agricultural education and university circles, as well as by consultants working to support the agroecological transition, and public sector officials implementing and monitoring research programmes. There are already three tools available free of charge online (at https://methode-idea.org/) to help different actors keen to use Idea4 (an Excel calculator, the Ideatools R package and the Web-Idea platform; https://web-idea.inrae.fr/). Idea4 is also intended to be used as a theoretical resource and evaluation tool for agricultural operations elsewhere in the world, revisiting and recontextualising societal objectives, indicators and calculation methods.

KEY POINTS

Idea4 is a scientific method for evaluating the sustainability of agricultural operations. It allows for the performance of sustainability diagnoses based on 53 indicators, identifying pathways to greater sustainability. Its theoretical framework proposes a dual approach based on the three dimensions of sustainability - agroecology, socio-territoriality, economics - and the five key properties of sustainable agricultural systems: the productive and reproductive capacities of goods and services, autonomy, robustness, territorial roots and overall responsibility. The dual perspective on sustainability made possible by these combined approaches represents a major innovation in the international landscape of indicator-based evaluation methods.

Outcome Trajectory Evaluation – Analysing the impact of research on policy

Boru Douthwaite,
Selkie Consulting Limited, Ireland

Background

As a problem-oriented enterprise - seeking to contribute to the emergence of solutions for making our society and our lifestyles more sustainable - sustainability science is directly concerned by questions surrounding the societal impact of research and how best to evaluate it. In its current contract of objectives, means and performance (2021-2025), the IRD is committed to "developing a comprehensive efficiency and impact strategy" (Objective 1.2) That includes developing appropriate methods for analysis and evaluation, of the kind proposed in the Miriades guide and already applied to numerous case studies. *Outcome Trajectory Evaluation* (OTE) is an alternative method focused on the impact of research on public policy.

Contact
bdouthwaite@gmail.com

Further reading

Cot M. *et al.*, 2022 – 'Societal impact assessments of research for sustainability science' in: *Sustainability Science*, Marseille, IRD Editions: 138-141.

Douthwaite, B., Proietti, C., Polar, V., & Thiele, G., 2023 – Outcome Trajectory Evaluation (OTE): An approach to tackle research-for-development's long-causal-chain problem. *American Journal of Evaluation*, 10982140221122771.

Renkow M., 2018 – *A Reflection on Impact and Influence of CGIAR Policy-Oriented Research*. Standing Panel on Impact Assessment (SPIA), CGIAR Independent Science and Partnership Council (ISPC), Rome.

Wilson-Grau R., 2018 – *Outcome harvesting: Principles, steps, and evaluation applications*. North Carolina, IAP.

The scope of the Outcome Trajectory Evaluation approach

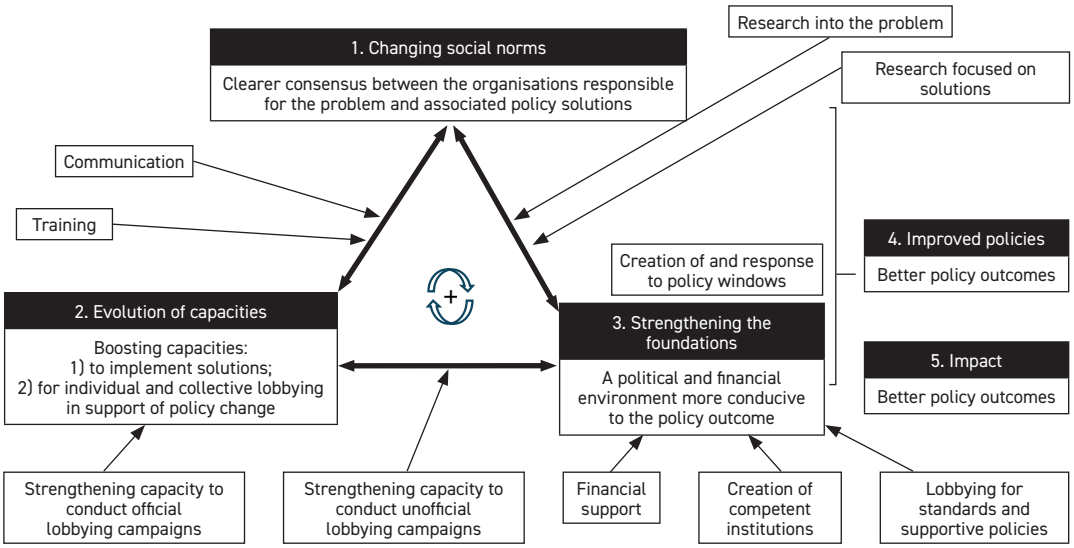
There are many ways of analysing the impact of research projects. One method is to focus on outcomes in terms of policy. In this context, an outcome is defined as "a change in the behaviour, relationships, actions, activities, policies, or practices of an individual, group, community, organisation, or institution." (Wilson-Grau, 2019: 2). An outcome can be said to be "societal" if it transcends the research framework; for example if farmers were to adopt a new technology developed by a research programme. Per Renkow's definition (2018), there are five main categories of policy-oriented outcomes: changes to laws and regulations, creation of institutions, changes in government investment priorities and budget allocations, innovations in the operations and management of government agencies and programmes, and international treaties, declarations, or agreements among parties reached at major policy conferences.

Key characteristics of Outcome Trajectory Evaluation

The OTE approach (Douthwaite *et al.*, 2023) is based on the hypothesis that any contribution made by a research project to a significant policy outcome is the fruit of a trajectory comprising different outcomes, an evolving, continuous and structured set of interactions between different types of actors, technologies, knowledge and institutions. OTE starts by identifying and describing this outcome trajectory, including research actors along with actors from other categories, before focusing specifically on the contribution of the research project to the outcome trajectory. To do this, OTE uses a middle range theory known as Policy Window Theory to delineate the outcome trajectory which led to the outcome which forms the object of the study. OTE successfully adapts *Policy Window Theory* to model the way in which evidence-based policy changes come about, when the evidence in question is supplied by research (Douthwaite *et al.*, 2023). Policy Window theory holds that such changes come about during "windows of opportunity," enabling "policy champions" to successfully connect two or more components of the policy process. Policy champions are firm believers in political solutions who are willing to devote their time, effort and reputation to advancing their cause. The components of the policy process include the way a problem is defined, the policy solution to the problem, and the politics surrounding the issue. Windows of opportunity are moments when progress can be made. They can be created by natural events such as pandemics, droughts or earthquakes. They can also arise from changes in government, budget cycles or landmark meetings and summits held as part of ongoing national, regional and global processes. Policy windows are often short in duration and may or may not be predictable.

Step-by-step evaluation process

• Step 1: select the policy-oriented outcome. The outcome selected as the focus of the study must be significant, clearly defined and indicative of an important contribution by the research project(s) in question. It need not be representative of the broader policy bent of all projects in this field. The outcome should be as specific as possible.



***The Policy Window theory* of how policy change occurs (Douthwaite *et al.*, 2023). The general strategies are represented by the unnumbered boxes associated with the results 1. 2. 3.**

• Step 2: identify and describe the outcome trajectory that produced the policy outcome. The evaluator compiles annotated historical timelines for each outcome trajectory, on the basis of interviews and analysis of written reports and existing publications, in order to firmly establish the chain of events and the causal mechanism in play. The evaluator makes use of Policy Window Theory to guide this research.

• Step 3: confirm trajectory timelines with stakeholders. The evaluator presents the annotated historical timelines to the interviewees, who challenge, complete and approve them.

• Step 4: detail the strategies used in these outcome trajectories in order to develop a theory of change (ToC) which will be validated in a workshop setting. The goal is to identify, based on the annotated timelines, the specific strategies employed by the actors involved in these outcome trajectories, contributing to more general strategies which, in turn, contributed to results 1, 2 and 3 as shown in the diagram. These general strategies are defined on an a priori basis, with the help of Policy Window Theory.

• Step 5: use the validated timelines and Theory of Change to answer the evaluation questions. For each outcome trajectory, the evaluator uses the confirmed timelines and the relevant ToC, as well as the interview notes and other resources, to answer the questions posed (e.g. if and how the research project made a significant contribution to the policy outcome).

• Step 6: subject the draft report to review for fact and inference checking. A draft of the final

case report is sent to the evaluation leader in order to coordinate the reviewing process and check facts and inferences drawn by the evaluation team. Comments and suggested modifications are taken into consideration at this stage. Any changes accepted or rejected are recorded and explained.

• Step 7: share the method and results. This dissemination may involve learning tools and information files, contributions to change narratives etc.

A useful approach for researchers

For researchers, OTE represents a middle range theory backed up by existing literature, setting it apart from most evaluations which base themselves on stakeholders' ideas of how change occurs. This approach can thus help researchers to better understand the societal outcomes they help to shape, perhaps without realising it. Using this approach may also help researchers to adjust their working practices, particularly in terms of their relationships with colleagues and non-academic partners. Such changes have the potential to deliver better policy outcomes. Nonetheless, one of the obstacles to expanding the use of OTE is that the drafting and reviewing of annotated timelines are time-consuming tasks. OTE also requires a certain degree of technical proficiency, which we would suggest makes it preferable to call in external experts (at least to begin with).

KEY POINTS

The impact - or transformative capacity - of research is a question of primary importance for sustainability science. In the meantime, results with clear policy ramifications are highly valued by the partners of development research institutions, including funding providers and supervising ministries. OTE is one of a raft of approaches aiming to unlock the influence potential of research communities, whether it be conscious or unconscious, encouraging researchers to be aware of this potential in their work. However, the time needed to conduct such analyses can be an obstacle to their implementation. In addition to the internal support mechanisms institutions might put in place, it might also be possible to relax the format of studies, simplifying the process without limiting the scope of their objectives.

The Sustainable Development Goals in the IRD's scientific publications

Laurent Guillou,
IRD, MEPR, Marseille, France

Background

The most recent Global Sustainable Development Report (2023) finds that progress towards the majority of Sustainable Development Goals (SDGs) is well behind target, that progress is either slow or non-existent, and that in some cases we appear to be moving backwards. The report also makes clear that further research is needed to better comprehend national and international contributions to the Sustainable Development Goals. In spite of the goals written into the text of research programmes, and the commitments of research institutions under the Agenda 2030 scheme, researchers rarely mention the SDGs in their published output. Some publishers and scientific databases now offer tools which are invaluable when it comes to identifying publications and analyses dealing with the SDGs.

Contact
laurent.guillou@ird.fr

Further reading
https://www.elsevier.com/connect/help-expand-a-public-dataset-of-research-that-support-the-un-sdgs
https://clarivate.com/webofsciencegroup/tag/sustainable-development-goals/

Bibliometric identification and quantification of the SDGs

Identifying and quantifying references to the SDGs in the bibliometric databases of scientific publications is a serious challenge. Numerous methods have been proposed, including:

• the Elsevier method: selecting SDG keywords in Web of Science, a scientific and technical information platform with access to bibliographical databases;

• the Auckland: a variant of the Elsevier method which uses more key words identified by means of textual analysis of publication titles and abstracts (search made via Web of Science [WOS]; https://doi.org/10.21203/rs.3.rs-2544385/v3);

• the WOS method: uses citation networks (links to articles citing articles in their bibliography) to establish a list of themes for each SDG (an internal indicator specific to the WOS platform);

• the Dimensions method: classification by an AI tool trained on search requests employing a vast set of keywords (this indicator is specific to Dimensions, www.dimensions.ai).

Equipped with WOS and DOI (digital object identifier) codes, it is easy to use these methods to examine a corpus of articles from a specific institution. While the limitations of such methods have been discussed in the literature - particularly their capacity to evaluate the contribution of scientific results to the SDGs, or their failure to take full account of publications in the human and social sciences sphere which are poorly represented in WOS - they are still useful when it comes to assessing the extent to which an institution's research priorities are aligned with Agenda 2030.

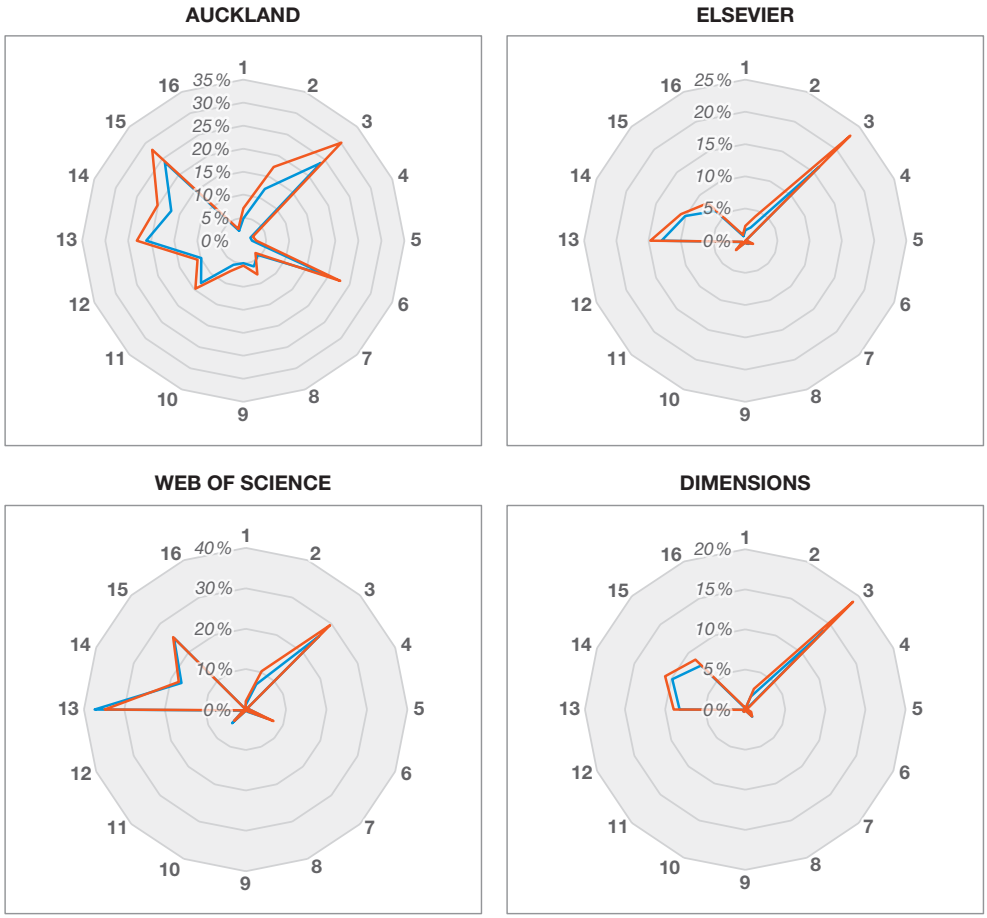
IRD's contribution to the SDGs

What results do we get if we apply this method to the IRD? Our first indicator, for the period 2017-2022, tells us that the corpus of publications emanating from UMRs under IRD supervision comprised 33,072 WOS articles; that number falls to 9,493 if we include only publications with at least one author based at IRD. This means that IRD researchers contribute, on average, to 29% of the publications of their UMRs pertaining to one or more SDGs. Within this corpus, the proportion of publications aligned with the SDGs is around 90% (for both perimeters - UMR and IRD). Nine out of ten publications by IRD members are thus aligned with the SDGs, a figure which compares favourably with the 66% global average. Our second general result is that, while some data may diverge depending on the method employed, different analyses are consistent on certain points:

• the 4 most well-represented SDGs in IRD output (UMR and IRD) are:

- SDG 3 (good health and well-being) corresponds to 25% of IRD output, on average,
- SDG 13 (climate action) corresponds to 20 % of IRD output, on average,
- SDG 15 (life on land) corresponds to to 18 % of IRD output, on average,
- SDG 14 (life below water) corresponds to 15 % of IRD output, on average;

• the 4 least cited SDGs are SDG 4 (quality education, mentioned in just 0.7% of IRD output), SDG 5 (gender equality, mentioned in 1.1% of IRD publications), SDG 9 (industry, innovation and infrastructure, 1.4% of IRD



Percentage of IRD publications associated with an SDG, based on 4 analytical methods (IRD perimeter in orange, UMR in blue). SDG 17 is not shown here, because the majority of articles involving search engine requests do not include it.

output) and SDG 16 (peace, justice and strong institutions, mentioned in 1.1% of IRD articles). This result may be attributable to the non-exhaustive representation of HSS publications in the WOS database.

If we compare these figures with the global mean values, the IRD is well above the international average when it comes to publications on SDGs 13, 14 and 15, but far below average on SDGs 4, 7 (renewable energies) and 9. Moreover,

IRD researchers (both UMR and IRD perimeters) tend to explicitly cite the SDGs in their publications: this tendency is especially evident for SDG 4 (despite the fact that IRD researchers publish relatively little on this subject) and SDG 5.

Mentions (or absence) of SDGs in articles

At the global level, only an extremely small proportion of academic articles explicitly mention the SDGs. This trend can also be observed at the IRD, where the SDG citation rate its very low: around 1% of UMR articles and 1% of specifically IRD articles Nevertheless, IRD researchers are more likely to link their publications to SDGs than UMR authors on the whole, and this is particularly true of SDGs 4, 5 and 12 (responsible consumption). SDG 7, on the other hand, is mentioned less frequently in IRD publications than the UMR average.

KEY POINTS

The four methods used in this study suggest that, in the years 2017-2022, the IRD's scientific output displayed a trend of specialisation in SDGs 3, 13, 15 and 24 (between 15 and 25% of IRD publication invoking each of these SDGs). However, the IRD publishes very little on SDGs 4, 5, 9 and 16. IRD publications invoking SDGs 13, 14 and 15 are more numerous than the global average. Proportionally speaking, IRD members tend to explicitly state the connections between their publications and the SDGs. While the results obtained using different methods are relatively congruent, they still raise questions as to the bibliometric definition of the SDGs, and whether it is preferable to use external methods or internal processes when constructing indicators. Different methods may diverge in terms of the number of publications they include, depending on the key words employed and/or the way in which the platforms train their algorithms. Implementing and SDG progress barometer at the IRD would allow for: 1) greater long term stability in SDG studies; 2) greater sensitivity to the specificities of the IRD at the institutional level; and 3) a strategic tool for monitoring activity.

Legal deposit: 2024

SUSTAINABILITY SCIENCE
UNDERSTAND, CO-CONSTRUCT, TRANSFORM
Volume 3

This third volume of contributions from members of the IRD community - scientists, experts, artists, project leaders and representatives of civil society - brings the total number of articles published on this theme since 2022 to over 100. Structured around the triptych "understand, co-construct, transform," these articles collectively amount to a compendium of sustainability science, a science which is rapidly emerging as a key response to some of the greatest challenges of the 21st century, and a catalysing force for the necessary societal transformations.

Institut de Recherche pour le Développement
FRANCE

www.editions.ird.fr