S&T&I FOR 2050

Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions

CASE STUDY: DATA AS REPRESENTATION

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1. OVERVIEW

The paper proposes three scenarios on the way data is understood and used in relation to the human and natural ecosystems by 2050. The final aim is to suggest the implications for the way R&I is organized and its challenges in each scenario.

In building these alternative scenarios the authors

- start from the most promising STI directions in *Data science & statistics*, for supporting the flourishing of ecosystems by 2050, as identified in a large Delphi consultation. These directions are: Big data sciences, Environmental modelling and simulations, Web-applications, and tools for decision-making (see Box 1). A review of the current situation along these directions is provided in the following chapter.
- differentiate the scenarios based on
  - the way humans see their role in nature, specifically as *protecting and restoring*, as *co-shaping*, or as *immersing and caring*[1].
  - the way data is interpreted in relation with reality, specifically as objective, as species-dependent, or as a molder of reality.
  - the significance given to indigenous knowledge, namely as contextual information, as a rich repository of observations, or as the ‘spirit of nature’.

The resulting aspirational scenarios (see Table 1 for a synthetic representation) are:
  - *To the maxx* – in which the technological trends of the early 2020s (pattern recognition through AI, greener and FAIR data, digital twins etc.) have reached maximal expansion. In this scenario, science supplies data and algorithms for decision-making, but scientific techno-optimism is confronted with the challenge of understanding and of justifying decisions.
  - *Radical responsibility* – in which a social technology (equal recognition through a system of rights) is extended to virtually all beings, human and nonhuman. Here, science is enlisted in support of bringing in the perspectives of different species but is confronted with the challenge of integrating these perspectives into broad models accepted by all.
  - *We, the life* – in which the driving force is a new level of consciousness gained by a growing number of biocentric scientists. Humanity relies on them to inspire ethically grounded worldviews, influencing the design of socio-techno-environmental systems.

While in the first scenario the R&I landscape is amplifying the concerns of today (data security, data driven authoritarianism, quantitative vs qualitative research), in the second one this landscape is more fragmented and even bureaucratised in an effort to accumulate knowledge about the different species. Finally, in the third scenario, the R&I landscape is radically different from the present, while recuperating part of the spirit of the early days of science: a primary preoccupation with ethical grounds, VIP scientists expressing their views at the crossroads with art and spirituality, with their apprentices and communities of followers not spared by cult accusations and clashes of opinion.

1 Warnke P., Erdmann L., Kubeczko K., Brodnik C, Könnölä T., (2021), *Deliverable 1. Scoping and draft concept paper.*, project Foresight on Demand:Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions.

2. THE MOST PROMISING STI DIRECTIONS

The chapter reviews the current situation of the most promising Science, Technology, and Innovation (STI) directions in the domain *Data science & statistics*, for supporting the flourishing of ecosystems 2050. The three STI directions (i.e., Big data sciences, Environmental modelling and simulations, Web-applications and tools for decision-making) were identified in a large Delphi[2] consultation carried out in 2022.

Box 1. **Results from the Dynamic Delphi Survey**
STI for flourishing ecosystems 2050
in the domain Data science & Statistics

A. The most ***promising Science, Technology and Innovation (STI) directions***, considering their potential to contribute to the capability of planetary ecosystems to flourish from now to 2050:

- **Scientific disciplines and fields reconfigured as 'big-data sciences'**: e.g. Ecology and ecoinformatics; Geography; Environmental sociology; Agritech; Disaster management; AI-based decision-making; Healthcare - epidemiology, pandemic management, database searches for disease markers, Big Data-based discovery of new targets in tumours; Genomics; Bioinformatics - such as through community-wide metabar coding; Biodiversity management; Forecasting
- **Environmental modelling and simulations:** e.g. Earth systems models; Climate fluctuation analysis; Models of soil microbial processes; Forest growth simulations; Models of hurricane wind disturbance; Geospatial data analysis; Deep-time, mechanistic eco-evolutionary simulations; Community-scale spatially explicit genetic simulations; Global emissions monitoring; Intelligent earth observation; Environmental modelling of climate change processes; Empirical data-driven modelling of species distributions and associated ecosystem services provision; Spatially explicit environmental change predictions in terms of species turnover, biodiversity change, and associated ecosystem services change
- **Web-applications and tools for decision-making**: e.g. To access economic and environmental data; To create scenarios for decision making; For public monitoring; To access ecological data; Online predictions on species turnover, biodiversity change, and associated ecosystem services

B. The *potential significant harms* that STI could inflict on the capability of planetary ecosystems to flourish from now to 2050:

- In Big Data, there are many ways to make mistakes: poor data, bad models, confounding, inappropriate generalizations, inbuilt biases.
- Big Data may be used by corporations for targeted marketing that is harmful to clients.
- Gaps in data collection, especially resulting from ignoring different or little-known regions, render models inapplicable and potentially harmful.
- Data can be misused to justify inadequate decision-making and to support the wrong ideas.
- Data science & statistics can potentially influence human behaviour, control human mobility, drive social/political decision making, deteriorate social capital.
- Big data collection may raise ethical issues pertaining to the infringement of individual autonomy, use of personal data without permission and manipulation.
- Computationally-intensive modelling and large data storage generate substantial power consumption.
- Data science raises issues of public security.
- Intentional or accidental creation of an autonomous AI weapon.
- Data-supported exploitation of natural resources may lead to the collapse of the relevant resources.

2 Dragomir B., Gheorghiu R., Andreescu L., Dimitriu R., Plescan P., Curaj A. (2022), *Deliverable 4. Future sheets,* project Foresight on Demand:Science, Technology and Innovation for Ecosystem Performance – Accelerating Sustainability Transitions.

3. SCIENTIFIC DISCIPLINES AND FIELDS RECONFIGURED AS 'BIG-DATA SCIENCES'

Perhaps the main argument for the importance of Big Data for environmental issues stems from the complexity of natural and social systems and subsystems. Big Data has been essential to the development of sophisticated models – see next subsection – for a variety of relevant phenomena and for sustainability-related interventions. It has also raised a number of specific challenges.

The increasing popularity of Big Data analysis has led to its adoption across fields and disciplines. This, in turn, has created an opportunity for collaboration, as more fields have migrated towards similar methodological toolkits. This collaboration is vital to environment-related pursuits, as the many subsystems engaged by fields such as earth and climate science, biology, medicine, urbanism etc. will benefit from related approaches and interconnection.

There are two main classes of Big Data trends in our context – one related to technical evolutions, the other to institutional advances.

Technical evolutions

As to the former, they are spurred by broad developments in areas such as breakthroughs in sensor technology, the Internet of things, automated machine learning, edge computing and "TinyML" (AI for small-data environments), and so on. As these advances have penetrated many scientific fields, they have enabled a variety of developments, among which the following:

In ***environmental science***, new technology has enabled data collection from a large variety of sources. Remote sensing has been employing devices ranging from satellites to drones to RADAR/LIDAR. Monitoring systems now include a broad variety of sensor technologies in the field, often providing real-time information to distant data centres. Sometimes, gaps in these collection instruments have been filled with "citizen science"-generated data; as well as by data mined from web and social media platforms to provide field measurements (e.g., of water or atmospheric pollution, a.s.o.). Last but not least, historical data – such as the records maintained by some national geological survey agencies covering one or more centuries – have been digitized and are available as inputs into models (Blair et al., 2019).

Many of these data sets have been employed for broad analyses of the climate, providing a much more accurate picture of the magnitude of climate changes – as well as an understanding of policy interventions that have worked around the globe (Runting et al., 2020).

In ***ecology*** and its subfield of ***ecoinformatics***, deep learning has been used to identify species, estimate biodiversity, or classify animal behaviours using, for example, large datasets from camera images and videos (Christin et al., 2019). Digital sensor data, brought together through initiatives such as eMammal and Movebank, have revealed the new potential of spatial ecology (Kays et al., 2020), while raising critical questions concerning the appropriate uses and combinations of sensors (Williams Hannah et al., 2020). Such findings have been employed to identify wildlife population declines due to patterns of animal behaviour that conflict with human activity (such as high road traffic areas) and to create adequate reporting mechanisms (Shilling, 2020).

Genetic research has been leveraged to study biodiversity via techniques such as environmental (eDNA) metabarcoding, which is heralded as a one of the key tools for the future of global conservation. eDNA coding promises community-wide analysis of diversity and interaction at a scale and cost previously unattainable (Kennedy et al., 2020). Such high-throughput sequencing uses samples extracted from water, soil, and air to amplify DNA to a level that enables the detection of species. The methods can be also used to reconstruct ancient habitats, analyse animal diets, detect invasive species, or study the interaction of plants and pollinators (Krista et al., 2019).

In human ***health*** in relation to the environment, Big Data has enabled advances in epidemiology, for example by combining health data with veterinary and agricultural reports on recent animal disease outbreaks (Bansal et al., 2016). Another line of inquiry concerns studying the impact of climate change on food safety and food-borne diseases (Talari et al., 2021).

Institutional advances

These and other developments in Big Data analysis and use – particularly for purposes of decision-making: see subsection 3 – have generated a number of concerns, the response to which has consisted in a series of institutional adjustments.

Perhaps the most important of these responses has been a sustained effort to ***open up access to data*** by eliminating barriers before researchers as well as other interested parties. To a considerable extent, this has been a reaction to the large quantities of proprietary data generated by large corporations involved in Big Data analysis. Openness is particularly relevant in the case of Big Data because the same data sets can be used for a wide range of purposes – or for similar purposes but in a variety of different models.

In sustainability and conservation, increasing access to data has made possible a variety of initiatives, among which the Global Fishing Watch, Global Forest Watch and global inter-tidal websites (www.globalfishing-watch.org, www.globalforestwatch.org, www.intertidal.app); "or user-friendly analysis tools, such as REMAP – a free application that utilizes the storage and analysis capacity of Google Earth Engine to map land cover change (www.remap-app.org)." (Runting et al., 2020)

The challenge of data ***interoperability*** is closely related to questions raised by proprietary nature and by other barriers to access. Given the wide range of sources from which systematic and unsystematic data sets are generated, pooling data, or using heterogeneous data sets in models often raises a variety of practical issues. Some of the solutions can be technical (automated data cleansing etc.), while others involve better standard-ization and shared practices.

An additional solution for interoperability, which results in many other key benefits, is the expansion of ***inter-national collaboration*** through the creation of data e-infrastructures providing high-performance and cloud services to researchers and policy makers. These can then be used for the purpose of research as well as for monitoring, early warning systems, or for the enforcement of certification regimes (like fair trade practices in agriculture).

Recent examples of large-scale collaborations around Big Data include the EU-funded EUXDAT "through which a multitude of data, analytics and computational resources can be accessed to monitor soil and crop health, optimise resource consumption, increase agricultural yields and sustainably manage land."[3] Similarly, the EU's Knowledge Centre on Earth Observation plans to leverage, for EU policy-making and in particular for the European Green Deal, earth observation data generated via the European Copernicus Programme and other sources.[4] A large common project of the UN Environment Programme, Google, and the EC's Joint Re-search Centre recently established "a web-based platform that fuses big data and environmental science to monitor [the] global freshwater ecosystem".[5]

Partly in order to generate more data (and more localized data), and in part as a project to democratize citizen's participation in and support for science and evidence-based decision-making, some effort has been invested in encouraging and supporting **citizen science**. Despite its challenges – citizen-collected data can add to data heterogeneity and raises additional reliability concerns –, this type of citizen participation in science has pro-vided examples of success. Among them: mySoil, an application developed a decade ago by the British Geo-logical Survey,[6] soon to be replaced by the UK Soil Observatory (UKSO); or the OPAL Soil and Earthworm Survey.[7]

3 https://ec.europa.eu/research-and-innovation/en/projects/success-stories/all/big-data-solutions-big-farming-challenges

4 https://joint-research-centre.ec.europa.eu/jrc-news/new-knowledge-centre-earth-observation-2021-04-20_en

5 https://www.unep.org/news-and-stories/story/plugging-data-gap-google-european-commissions-joint-research-centre-and-un

6 https://www.bgs.ac.uk/technologies/apps/mysoil-app/

7 https://www.imperial.ac.uk/opal/surveys/soilsurvey/

4. ENVIRONMENTAL MODELLING AND SIMULATIONS

Models, whether used explicitly or tacitly, underlie most human activities that rely on even basic forms of knowledge. (In this sense, modelling is inherent to human thinking.) With the rise of science, more systematic or formal models have been used to describe the phenomena of interest and to make predictions. Models have been recognized as essential in the testing of our theories of the world, but they are equally important in expanding or redefining these theories. Crucially, models force us to specify and thus help us clarify the assumptions we build into our views and approaches to the phenomena of interest. Since explicit modelling has been used as a tool in decision-making more generally, not just in science strictly speaking, the usefulness of models in the monitoring and evaluation of interventions has also become very clear.

A taxonomy of models function of analytical technique

Principal analytical technique	**Sub-categories of techniques/modelling approaches**
Equilibrium models	General equilibrium models, partial equilibrium models or sectoral models, mass balance equation models, optimisation models
Empirical-statistical models	Rule-based models, cellular automata, agent-based models, multiple regression models, area-based matrix approaches, stochastic approaches, econometric models
Dynamic system models	Linear/non-linear programming models, population dynamics models, impact assessment models, integrated assessment models
Interactive models	Expert judgement frameworks, decision support systems, educational gaming, information tools

Source: European Environment Agency (2008)

As measurement and data collection tools have improved and computational power has increased, particularly dramatically during the past decades, the use and intricacy of formal models has expanded just as drastically. Models have been designed for increasingly more complex systems – environment-related systems being a case in point. The explosion in modelling seems to have covered everything from soil to the atmosphere and from water systems to the subsurface; models have been developed for entire ecosystems, including global ones, or for limited species and geographical areas. Thousands of centres in universities, research institutes, national and international agencies and companies are currently developing or running advanced modelling techniques on subjects relevant to environmental issues. Environment-related modelling activity has brought together researchers across disciplines and has been prominently featured in well-publicized reports, in the design of climate change strategies, and in assessments by international agencies such as, most famously, the UN's Intergovernmental Panel on Climate Change or the EU's European Environment Agency.

Major national and international research funding programmes have dedicated funding lines for model-development. ClimateEurope – a Europe-wide network for researchers, suppliers, and users of climate information – provides a list of recent relevant initiatives on Earth System modelling, Climate Observation and Climate Services, most of them funded under the EU's Horizon programs. To pick just one additional example, the US National Academy of Science, Engineering and Medicine's National Strategy for Advancing Climate modelling is already a decade old (2012). The current US administration has just boosted the Department of Energy's funding for research on earth and environmental modelling by 17%, while the National Science Foundation two main programs on Climate Science and Sustainability research (U.S. Global Change Research Program and Clean Energy Technology), both with an important modelling component, have topped 1 billion USD in 2022.[8]

As the above makes clear, environment-related modelling is today very diverse thematically. The Delphi consultation mentioned previously, which selected “Environmental modelling and simulations” as a key trend in STI, illustrates this diversity in terms of the fields of modelling considered highly relevant or representative by Delphi respondents:

> Earth systems models; Climate fluctuation analysis; Models of soil microbial processes; Forest growth simulations; Models of hurricane wind disturbance; Geospatial data analysis; Deep-time, mechanistic eco-evolutionary simulations; Community-scale spatially explicit genetic simulations; Global emissions monitoring; Intelligent earth observation; Environmental modelling of climate change processes; Empirical data-driven modelling of species distributions and associated ecosystem services provision; Spatially explicit environmental change predictions in terms of species turnover, biodiversity change, and associated ecosystem services change.

This list of assorted modelling approaches illustrates not only the current thematic variety (from wind to genes and to the climate as a whole), but also the technical diversity of approaches. Model-building currently employs a variety of categories of analytical techniques (see the table above) (EEA 2008) – and often combines them. Judgmental models, based on expert opinion, represent an additional category. Models, and climate models in particular, also differ in geographical and temporal resolution (the space and time increments for which predictions are made).

This explosion of models predicting and describing environment-relevant phenomena within and across potentially related fields of research raises a number of potential issues. Some of them are specific to Big Data collection and analysis and have been alluded to in the previous subsections. Other issues are specific to modelling. They extend beyond the traditional modeler’s dilemma of how to choose the right level of simplification, a particularly thorny issue given the intricacy of environmental systems (Allison et al., 2018).

Among the more recent concerns, one is related to the impact of the diversity of available models on the (un)certainty of our knowledge and, as such, of decision based on this knowledge. To what extent is the knowledge produced by such a variety of modelling enterprises manageable for practical purposes? What are the risks of selecting some models at the expense of others?

This is closely related to a second concern – the capacity to integrate these types of tools in decision-making. Are decision makers equipped to choose the best models? Do they have the capability - and drive - to pool models and their results in order to improve the knowledge base for decisions?

A third matter concerns the gaps in knowledge or in coverage that persist despite the diversity of models, and which this diversity may in fact obscure. Both modelers and decision makers acting on models are exposed to a variety of well-known biases (Glynn, 2017). Are there issues or problems that are not adequately covered by models at the present time, perhaps due to a lack of interest by researchers, or because they are less amenable to available analytical techniques? More broadly, who defines the issues of interest? Who participates in constructing the broader goals which the development of models is supposed to serve?

A further question concerns the transparency of the models to both decision makers and the general public. The former may not completely understand the assumptions that increasingly complex models are based on; decisions may be, under such circumstances, grounded in various types of misunderstandings or misperceptions. As for the general public, it will be at the mercy of other parties’ explanations concerning the significance of model results and the measures ahead.

Finally, there is a concern that the more computationally intensive modelling will become, and the bigger the data and the data storage needed to feed the models, the larger the power consumption.

8 https://nsf.gov/news/factsheets/Climate%20Change%20Fact%20Sheet.pdf

There is a variety of efforts in the broad field of environmental modelling to respond to some of the concerns listed above. Some start from the understanding that modelling is a social process and propose holistic frameworks for model assessment from a multi-dimensional, multi-perspectival perspective (Hamilton et al., 2019). A complementary approach is to create participatory modelling processes, whereby various stakeholders – including but not limited to decision makers – are engaged in conceptualization, model-building, and model assessment (Voinov et al., 2018). Solutions and tools have been proposed to increase data accessibility, both in terms of availability and, importantly, of intuitiveness, i.e., facilitating ease-of-use (Will et al., 2021). These and other developments have been part of an effort at paradigm change, sometimes described under the name of Integrated Environmental modelling (IEM) – a holistic approach aiming to resolve issues of scale, bridge scientific disciplines, bring together stakeholders, and translate the results of modelling into knowledge appropriately packaged for decision-making (Laniak et al., 2013).

5. WEB-APPLICATIONS AND TOOLS FOR DECISION-MAKING

Evidence based policy and beyond

Evidence-based policy can be defined as "encompassing (1) the application of rigorous research methods, particularly randomized controlled trials (RCTs), to build credible evidence about 'what works' to improve the human condition; and (2) the use of such evidence to focus public and private resources on effective interventions. Evidence-based policy emerged first in medicine after World War II and has made tremendous contributions to human health" (Baron, 2017). In complementary fashion, the importance of "policy narratives" has been emphasized: "advocates of scientific evidence need to tell good stories to grab the attention and appeal to the emotions of policymakers." (Davidson, 2017) The idea of a "**good governance of evidence**" is a related concept that highlights "the use of rigorous, systematic and technically valid pieces of evidence within decision-making processes that are representative of, and accountable to, populations served" (Parkhurst, 2017).

Multiple perspectives

Co-production is a way of aligning knowledge and action that is critical for sustainability. With already a long history, co-production requires participants to be reflexive about the inherently political nature of producing knowledge. As a process, co-production raises additional challenges of inclusiveness, credibility, legitimacy, and accountability (Miller et al., 2020). In an attempt to integrate uncertainty in the modelling of socio-environmental systems, participatory methods make use of **multiple scenarios** (Elsawah, 2020).

A set of practices with a more pronounced applied character, **participatory budgeting** has its roots in the US history of public hearings and citizen budget committees and in South America in the 1980s. The different practices cover one or more of the steps of idea generation, elaboration, production, and impact; and the mechanisms include public meetings, focus groups, simulations, committees, and surveys (Bartocci et al., 2022).

For cases in which the interests of the actors are entangled but not necessarily converging, simulations have been designed using **agent modelling techniques** (see for instance He et al., 2018, for Shale gas operations; and the previous subsection).

Another way of dealing with complexity is to **combine frameworks** of analysis. Examples include the use of alternative models in fields like conservation (Schwartz et al., 2018) or energy risks (Wang et al., 2018).

Intuitive data

There is a growing trend both in the supply and the demand for more complex/interactive **data visualization**. Examples include *geospatial dashboards* for monitoring smart cities (Jing et al, 2019) or urban heat vulnerabilities (Karanja J. et al., 2021); 3D models (Kilsedar et al., 2019) and augmented reality for flood visualization (Haynes et al, 2018). Visualizations play a more prominent role in dynamic phenomena like natural disasters (see for instance Millet et al. 2020 for hurricane risk communication).

Long-term perspectives

The challenge of sustainability gives decision an implicit prospective dimension. The most common tools and methods used coming from foresight (Delphi consultations, scenarios and visioning) and life cycle assessment - LCA (see for instance Nwodo et al, 2019; and Hollber et al., 2019, for LCA in building environment).

Human-machine collaboration

A recent study shows that "human managers do not want to exclude machines entirely from managerial decisions, but instead prefer a partnership in which humans have a majority vote" (Haesevoets et al., 2021).

For some "machines should take care of mundane tasks, allowing humans to focus on more creative work" (Jarrahi, 2018), while for some this represents the chance of reducing human bias (Xiong et al., 2022). The explainability of AI is one of the most challenging aspects (Baredo Arrieta et al., 2020), so much so that some consider it illusory, calling for the return to interpretable models (Rudin, 2019). As a response to the existing concerns, some stress the investigative role of big data (Wüest et al., 2020), while for others **transparency feedback loops** (Akash et al., 2019) seem to be the wholly grail of human-machine collaboration.

6. SCENARIOS 2050

This section contains the full text of the three scenarios mentioned in the introduction, each with a brief summary introducing the key ideas. The scenarios are preceded by an explanatory table.

The table below describes the links between the three general ecosystem perspectives identified in the project (Protecting and restoring, Co-shaping, Immersing and caring), the key STI trends identified in the consultation (common to all scenarios), and the role of data and indigenous knowledge (two of the drivers varying across scenarios).

The table then offers a systematic summary of the three scenarios across several dimensions, including implications and risks.

Table 1. Logic of the scenarios

	Perspective 1. Protecting and restoring	Perspective 2. Co-shaping	Perspective 3. Immersing and caring
DRIVER: Key STI trends	• Big data sciences • Environmental modelling and simulations • Web-applications and tools for decision-making		
DRIVER: Significance of data	Data reflects "objective reality"	Data is relative to the view from each species	Data molds reality, the glasses we see through and ultimately constructs reality
DRIVER: Indigenous knowledge	Limited uses, mainly for contextualisation of information	Indigenous knowledge is a rich source of info about the habits, needs and interdependencies of the various species	Indigenous knowledge is about the spirit of nature, an overarching value and transcendental reference
Title	***To the maxx***	***Radical responsibility***	***We, the life***
DESCRIPTION	An amplification of current trends, with a focus on technological instruments Digital twin	A radical amplification of current *social* technologies (recognition and rights), with a focus on the bureaucratic technology of extending rights to all living beings	A radical change in perspective, in which some humans get the biocentric view, i.e., the perspective from the Life Biocentric scientists - combining classic scientific inquiry and meditation and indigenous knowledge, some get the

	Algorithmic decision-making Global Data Centre Network infrastructures IoT (security & privacy issues)	Living beings are granted full recognition, manifested in terms of equal rights An extensive rights bureaucracy enforces full equality Living creatures are represented in a global legislative	awareness of Life as unitary and as the creator of reality Their wisdom is applied in (re)designing human ecosystems (and relation with Nature) Their knowledge is more inspirational, contextual, and even person related
IMPLICATIONS: Ethics	The aftermath impact	Inclusiveness in design and implementation	The very scope of knowledge creation
IMPLICATIONS: Science policy	Increasing role of science for policy, but not as an advisor, but as provider of knowledge into the complex algorithmic decision models An increasing demand for measurability, detrimental to qualitative research	Increasing efforts to accumulate knowledge about the different species Representatives of species embody scientific, ethical, and political skills	Artifacts at the interplay of science and art define the new frontiers of knowledge Apprenticeship in science as assimilation of the ways of the masters
RISKS	The more we understand, the further seems the capacity to actually control the phenomena The complexity of decision models may actually dilute responsibility	Decreasing trust in bureaucratic elites Increasing social antagonism - it becomes difficult to balance among the many interests of the many species (not to mention fu-	The reputation mechanisms may not discern moral-by-design visions from shallow constructs made to please audiences Charisma of established VIP scientists may sometimes block new avenues of science

	The more radical the innovation, the larger the gap between adopters and the left behind (technological divide) ‘Security’ threats: the more radical the innovation, the more it can be capitalized by rogue individuals and groups The rise of hyper-technological authoritarian regimes / systems (China) Resistance to technology: neo-luddism and other forms of protest or rejection	ture generations across all species) Fragmentation of research Bureaucratisation of science, increasing orientation towards negotiation Ever increasing need for finding common ground	Difficulties in generating actionable pronouncements from the bio scientists

6.1. Scenario 1: *To the maxx*

Summary
In this scenario, the technological trends of the early 2020s – pattern recognition through AI, greener and FAIR data, digital twins etc. – have reached maximal expansion and, in some cases, have over-delivered.
The result of the proliferation of technological solutions has seen a substantial increase in technological optimism, the belief that technological advance can alleviate social concerns and even cure social ills. Or, at least, this is the rhetoric promoted by officials, corporate offices, and techno-gurus and popularisers.
However, absent substantial changes in social structures and mores, the flipside has also become apparent: scepticism of AI-based decision-making and the purported loss of autonomy the latter implies has increased, the growth of neo-luddite movements has accelerated, and rogue actors are exploiting new types of security failures to showcase technological weak spots and blind spots.
Some actors thus argue that, by treating data as the mirror of reality and technology as the solution to be sought in all circumstances, techno-utopians have given up on genuine understanding. Consequently, there is a creeping sense that technological complexity in decision-making is diluting individual and collective responsibility since bad decisions can now be blamed on machines. Furthermore, the 'success' of repressive hyper-technological authoritarian regimes is raising the spectre of Big Brother even in consolidated democracies.

Key concepts: acceleration, data saturation, full AI integration, resistance to technology

Yesterday's techno-utopians were right. The budding technologies of the early 2020s took no more than a decade to reach maturity. Hype was not exaggerated, after all. All it took to enable today's technological boom was a few key scientific breakthroughs and some political willpower.

Perhaps the biggest advances have been made in sensor technology and deployment. Not only have sensors improved technologically – with unprecedented strides in miniaturization, fusion, and resilience –, but their diversification enabled unparalleled embeddedness. Sensors are now essentially ubiquitous in bodies and environments large and small. Smarter sensors with analytical capabilities have improved response times, decreased network congestion – and thus energy consumption – and crucially and surprisingly to some, have enhanced privacy. Areas as different as agriculture, health, industrial equipment maintenance, and disaster management have been substantially impacted.

Digital twin technology has been adopted across the board

In healthcare, for example, access to services in the developed nations has been extended even to the most remote areas, while in the developing nations the main barrier to such an extension remains the adoption of telemedicine gadgets outside the cities and large towns. Alongside such progress in spread, medicine has also personalized, with digital-twin technology leading to breakthroughs in many respects, treatment, and tailoring drugs key among them. Some argue that medical education is experiencing, due to the same developments, a rejuvenation without parallel in a century.

Digital twin tech is now well integrated in urban decision-making, with most major cities around the globe – and many smaller ones – having a full-fledged digital twin based on real-time sensor data, semantic data, and simulations. Some of these cities have attained, thanks to the prevalence of sensors and other data sources, a level of cyber-physical integration that has led to palpable improvements in the management of utilities, services (traffic control being the most evident), and even urban crime. Furthermore, as most cities use similar digital twin designs, with a considerable level of standardization and interoperation, successful interventions – though so far mostly tweaks – have been easier to transfer around the globe.

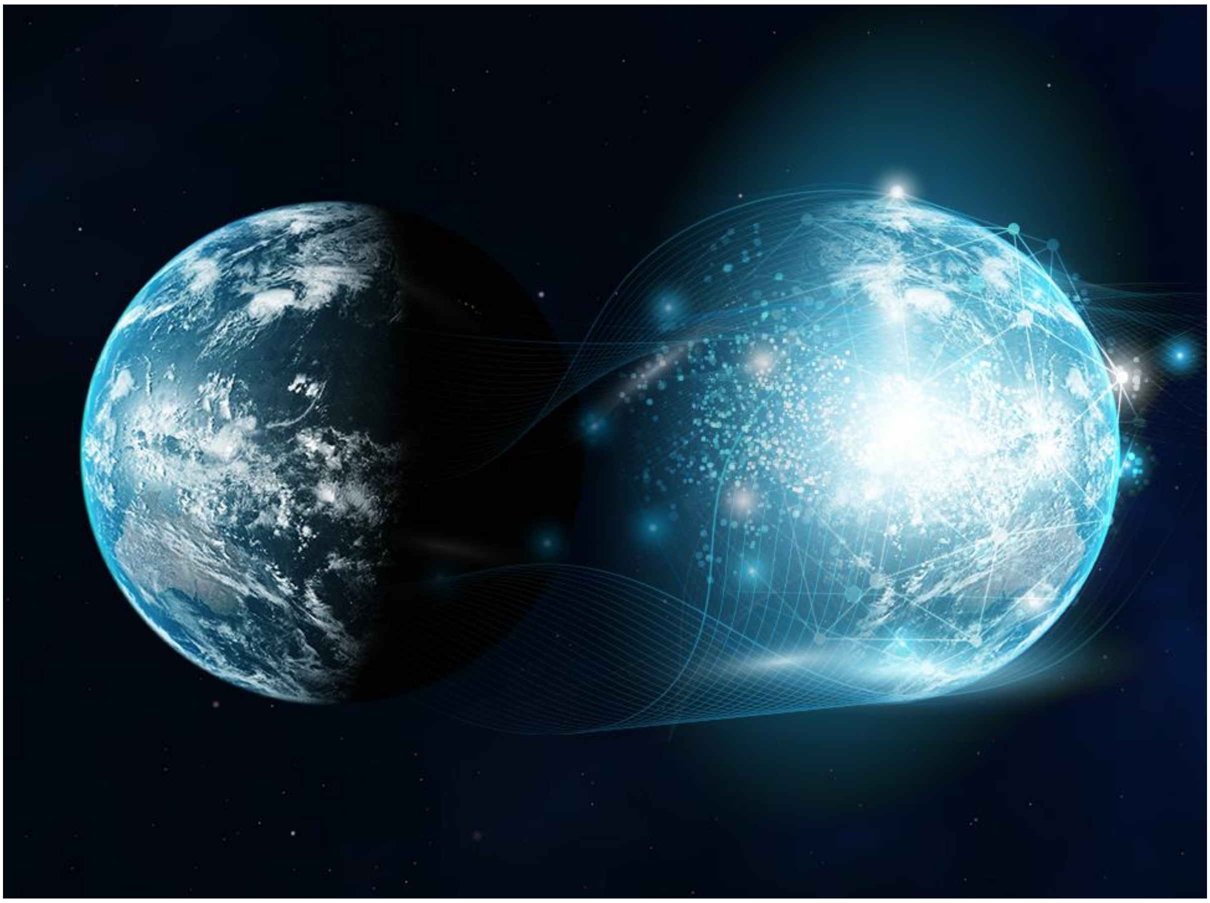


Image source: https://universe.wiki/2022/02/15/what-is-the-esa-earth-digital-twin/

Full integration of AI modelling and digital twins in decision-making

Support for the integration of AI modelling and digital twins in decision-making managed to overcome the initial scepticism of more conservative political elites and scientists. Leveraging indigenous knowledge has also proven useful, firstly by assisting in the improvement of models in key ways; and secondly by persuading the more ecologically and locally oriented constituencies that their concerns are being addressed. Ultimately, however, what sealed the fate of the general adoption of these technologies was their success – at least according to some proponents – in the prevention and mitigation of several disaster events, both natural and man-made. Among the former, the best-known case of success was the mitigation of several rounds of Australian bushfires, attributed mainly to excellent predictive modelling based on data collected from a wide array of embedded sensors. This and other similar events catalysed public support and overcame barriers to AI integration in decision-making, at least in some nations. Others followed suit.

Global Data Centre Network infrastructures

All of the above has been made possible by massive investments around the globe in Data Centre Network infrastructures, which have increased access to data and computational resources and have facilitated model integration. The infrastructures have also alleviated somewhat the energy consumption problems of the previous decades. Not only have DCNs substantially improved data crunching capabilities, but they vastly optimized utilization under conditions of a rapid increase in the demand for computing power. Furthermore, by relying mostly on green energy and innovative cooling solutions (also enabled by sensor technology), the networked infrastructures proved able to minimize energy waste.

The gap between decision and justification

The developments described above have generated a number of challenges. Perhaps the most serious one has been the real as well as subjectively perceived gap between algorithm and decision output – or, better said, between decisions and their justification. Although all trains run on time, city traffic is fully optimized (though still cumbersome in many places), and water use is taxed at exactly the right levels to disincentivize excessive consumption, many algorithmically generated policy decisions appear surprising or baffling. While they often work (or seem to), when measures are counterintuitive, they frequently generate criticism and resistance.

Social gaps and gaps among nations

At least in economically advanced nations, some of the social gaps have been bridged by widespread technological adoption and by optimized decision-making. Nonetheless, the increasingly smaller numbers of those left out have experienced a larger marginalization and disfranchisement. Furthermore, where the - still relatively rare - decision-making failures have been substantial, the consequences were harder to redress and politically very costly.

Given cheap technology, the gaps among developed and developing nations have not broadened in relative terms. Sometimes, the opposite has been the case in economic terms. Nevertheless, the economic successes and increased political stability in repressive hyper-technological authoritarian regimes has proven tempting in some developing nations. In global terms, therefore, democracy indices have recorded a moderate decline.

Algorithmic decision-making has been driving political disengagement

Politicians have tried to mitigate the rising distrust in data integration in decision-making, but in practice this has meant armies of consultants and technology experts – popularly known as “explicators” – struggling to translate policies into ordinary language and common intuitions. This approach has not been without success, particularly because the advance in visualization technology has mesmerized many concerned citizens. Nevertheless, these translation efforts have also led, among a considerable share of the population, to the perception that politicians are clueless and, at best, only retrospectively capable of justifying their decisions. In other words, politicians are superfluous. Several very publicized epic fails, usually consisting in bumbling explicators desperately flailing around for plausible accounts of a certain measure, have deepened some people’s cynicism about or disengagement from politics.

In some instances, however, the reaction has been engagement – in resistance to the new “data-based politics”, as it is occasionally called disparagingly.

Security in IoT

The ubiquity of IoT has also recently led to serious concerns over the security of gadgets ranging from connected intrauterine devices (which look for signs of incipient infection while methodically counting the number of annihilated sperm) to self-driving vehicles.

The latter, in particular, created a major global panic when a fleet of tens of thousands of automated cars marched on Washington. The vehicles, manufactured by TessX, formerly known as Tesla, were hijacked by a group of (ironically tech-savvy) anti-technology activists parodically self-entitled “LuddX”. The city and most of its services were essentially paralyzed for many weeks, leading to mass migration of the population and a shutdown of the federal legislature. The hijacked vehicles were strategically placed around the US capital so as to block access to the headquarters of the federal and local administration. The hijacked cars sometimes ‘danced’ (moved around) in coordinated fashion to block the advance of heavy military equipment deployed by the government to break the blockade, and even threatened to self-destruct in concert in a conflagration of epic proportions. (TessX assured the population that the cars have no such capability, but judging by the results of several polls conducted at the time, the people and the politicians were unpersuaded by the reassurances.)

Sensor-resistance movements

This and other more or less similar events expanded an anti-sensor social movement which now threatens to reverse somewhat the developments of the past years. After a golden age of integration in many organisms and virtually in all environments, the pressure to discard sensors has been mounting. In a global wave of reactions which some have hailed as “a return to human sense(s)”, many individuals are abandoning even such ancient technologies as home security, fitness bands, and modern defibrillators.

In agriculture, the anti-SMO (Sensor-Monitored Organisms) movement, spearheaded by several Evergreen Parties experiencing a renaissance around Europe, has managed to get the European Parliament to pass legislation on the labelling of foods and other items produced or manufactured from sensor-monitored plants, livestock, and even raw materials. Additionally, the pseudoscientific ideas spread by the fringes of this movement – that even minuscule sensors drastically alter the behaviour of living beings and may even spoil their DNA – are rapidly gaining ground, particularly among the very educated.

How exactly the strides in technological saturation and mounting techno-scepticism will be reconciled remains, at this stage, anyone’s guess. The European Union’s new RDI programs are now lavishly funding ‘reconciliation’ research, amid persistent background fears that weakening technological advances might weaken the continent’s competitiveness against nations that are not bothered by such details.

6.2. Scenario 2: *Radical responsibility*

Summary

The second scenario is also one of radical amplification - this time around in social *technologies. In this story, the world is moving towards equal recognition for human and nonhuman beings, defined in terms of a* system of rights *extending to most and, ideally, to all creatures. The human commitment to the environment and other species has reached a radical expression through the acknowledgement and implementation of full species egalitarianism, granting all species equal moral standing (Schmidtz, 1998). Once global human society has accepted the idea that the human understanding of nature is just one among many perspectives available, and should not be imposed on other species, a balancing (or interest arbitration) system has been set in place. This consists of an international system of laws, an international inter-species legislative, and a bureaucracy designed to ensure fair negotiation. While the establishment of this planetary legal system and of the legislative has been an unhoped-for success, it is experiencing familiar challenges. The ‘rights bureaucracy’ is increasingly mistrusted, and its purportedly high-minded elitism is under attack. The attacks come both from within (bureaucrats and elected politicians complaining about the failure to fully implement species egalitarianism), and from without (those pressing for an acknowledgement of the unavoidable pre-eminence of humans). Worryingly, both camps accuse science of being perverted. The first group claims research is still much too wedded to human interests and perspectives. The opposite camp complains that, on the contrary, science has been parcelised and siloed based on species perspectivism, and therefore an integrated outlook providing practical guidance acceptable to all has become impossible.*

Key concepts: recognition, pan-species equality, fair inter-species negotiation, perspectivism, anti-elitism

The days when rhinos and elephants were poached for their horns, royals would invite oligarchs to hunting parties, and millions of birds were unceremoniously sacrificed to wind turbines are long gone. In fact, not so long: the world was suddenly awakened not merely to the plight of animals, but also to their dignity, insightfulness, and resourcefulness. A wave of animal-oriented activism swept the global conscience - according to some, much like in a religious revival - and later extended to all living beings. The movement for equal species recognition gained almost universal support and proved able, surprisingly quickly, to establish a global system of rights for all creatures.

Living beings are granted full equal rights

In practice, this entails a legal system that, in some key respects, does not discriminate between human and other, non-human, creatures. The latter are represented at two main levels. The first is the level of individual animals whose interests may be affected and who may sue in their own name – through human representatives (Sunstein, 2003). The second level is that of (some categories of) policy-making, especially policy envisaging structural changes and conditions, where animal genera or families are represented by dedicated advocates in decision-making bodies.

Image source: https://eco-intelligent.com/

An extensive rights bureaucracy enforces full equality; living creatures are represented in a global legislative

Under these arrangements, a class of bureaucrats – "animal advocates" – exists whose sole mission is to represent animal genera or families (the basic units of representation, although, for simplicity, the term "species" is commonly used instead) in organizations at various levels of decision. Some ecosystems, such as corals or even individual atoll islands, benefit from similar representation. Perhaps the most well-known and, indeed, the archetypal organization of this type is the Poly-species Parliament, a global legislative body that sets the broad frameworks for lower-level decisions with substantial impact on species and the environment more generally. The human and many other species are represented at this level. The Parliament is mirrored by other organizations at lower decision-making levels, whether global, regional, or local.

These species-accommodating decision-making bodies are naturally complemented by species-specific consultants, advisers, and analysts, among which scientists are perhaps some of the most prominent. There are currently many research centres around the world serving the interests of each single represented species, and a number of professional scientific bodies have been founded that are defined by the constituency they serve (for example, the Global Association of Pooch Scientists).

The role of science in advancing full equality

Science has played a particularly prominent role in advancing decisions with respect to species equality. Researchers have been called upon to replace a human-centric perspective with species- or ecosystem-centric ones. Indigenous knowledge has been mined for ancient insights on animal behaviours and, in more extreme - and still somewhat contested - cases, for insights into animal consciousness. One effect has been an undeniable synergy among particular species-related perspectives. On the other hand, some argue that species pluralism in research has rendered scientific integration more difficult and even politically fraught.

Implementing true equality across all species is considered by some still an unfulfilled promise; activists demand full inclusion

The radical expansion of animal rights is being contested, however, though usually because it is not radical enough. Some activists press for an even more egalitarian approach, since under the prevailing arrangement not all genera or families are represented; and even for those that are, the true level of representation is not actually similar. For example, dogs and cats are represented as such, i.e., separately from the other canidae and felidae, respectively, which are lumped together. Other creatures are represented only at phylum level – the annelids, for example, triggering protests by advocates that most ringed worm species are crucially different from each other, and that to treat them in unitary fashion is to radically misunderstand their varied, sometimes conflicting interests. There are, then, extreme activists who call for a truly Pan-species Parliament, which should grant representation to forms of life presently excluded, such as various microbes, even some that are damaging or lethal to humans and to other families of non-human beings.

Parallel trends in human society: the rediscovery of indigenous knowledge

In response to criticisms of the prevalent data-collection regime as working under pretensions of universality and of separation between knowledge and governance, some have called for a better integration of indigenous knowledge in the human mindset (Latulippe et al., 2020). There is a notion that the latter is supposedly better at understanding other forms of life and may give rise to more persuasive, contextual narratives for data-based policy (Hammer, 2017). As a result, many animal representatives are becoming more diverse themselves, counteracting the trend of indigenous knowledge erosion (Aswani et al., 2018).

As animal advocates diversify, one proposal is to "de-humanize representation" by taking human advocates out of the picture to the largest extent possible. The main proposal, rapidly gaining ground, is to replace human advocates with bots. The main project is to enable the latter to develop autonomously, in line with the experience they share with the creatures on behalf of which they act and speak. Opponents of this trend have expressed the concern that such bots may, in time, come to dominate the species they represent - or, rather, mis-represent.

This being said, there are still voices claiming that species-perspectivism is politically divisive, rather than integrative. They argue that it would be more honest to recognize that species representatives still pursue very personal (and thus very human) interests, even if the latter are tied to the welfare of particular species.

The use of data follows the principle of perspective- or interest-pluralism; challenges against pluralism are raised by the species-relativist position

The organization and use of data under this arrangement offers a good illustration of the issues arising more broadly. Data collection follows the principle that each species (genus or family) has its own perspective on the world. As a result, all the equally represented beings have developed, through their bureaucracies, their own models of the environment(s) and their own kinds of data. The latter can be extremely fine-grained and are usually also quite varied. Cat advocates, for example, who are among the most ferocious supporters of the (in this case) *catus* worldview, have amassed huge data sets on the impact of surface densities and textures on purring, not only for a large number of subspecies and sub-subspecies of cats, but for almost all individuals of the species living together with humans. (Human cat companions are, under laws passed over a decade ago by the Parliament, obliged to install a wide array of sensors to constantly monitor this and other cat-specific variables, though individual cats retain the right to refuse to wear any on- or in-body device.)

The key challenge in this respect is that, as species-specific data grows more detailed as well as more particular, it has become difficult to integrate in all-purpose ecosystem-level models. Indeed, there are claims that such models would intrinsically violate perspectivism.

The prevalence of data collection and modelling by species-specific analysts has led to an explosion in power consumption

This data-centric approach to the rights of beings, which not all animal representatives share, but which is very widespread, has generated a serious acceleration in computational and storage needs. On the positive side, it has led to rapid and quite radical advances in the development of sensors, and especially biosensors and BioFETs, needed to respond to the huge variety of bodies and environments now housing them. The extension of AI across species, particularly to deliver species-specific services, has vastly improved algorithms.

On the worrying side, overall power consumption has been increasing several-fold every few years, prompting a large number of cost-benefit analyses of investment in data infrastructures – from the perspective of each represented species. Furthermore, the inability to reconcile these analyses has often led to delays in decision-making.

Competition for data to satisfy radically different, species-specific concerns generates clashes among species representatives and threats to data security

In this context, data security has posed particularly difficult dilemmas. One crisis, which almost led to the disestablishment of the Parliament, is worth recounting, among other reasons because it also involved cats. A synchronized breach of several large data centres by two groups of *unofficial* cat supporters (self-styled "The Katerrorists" and "Kattack") exposed, among others, almost the entire network of underground tunnels painstakingly charted over many years by the *official* teams of scientists working for underground rodents and for the muridae family as a whole. Although it was not entirely clear how this type of information could be communicated to individual cats, and therefore what the real impact on the rodent population might be (cat advocates said it would be vanishingly small, while muridae representatives argued it might lead to extinction), the breach was considered a major challenge to the poly-specieist arrangement. It took almost a full year of negotiations for the clash to subside and for the Parliament to fully return to work. (Part of the compromise was for rodent advocates in the global legislative to surrender some of the comfiest seats in the legislative building to cat MPs.)

Interest-pluralism exposes the difficulty of reconciling the radically different interests of earthly species; one expression of this conflict is the heterogeneity of data and models

This case illustrates a more serious concern, namely, the conflict of worldviews, which some theorists have described as a "clash of specielizations". While some species advocates – most notably, human representatives – have insisted on a poly-specieist perspective, wherein interests should be negotiated among fully equal species, in a few cases advocates have rejected this egalitarian approach. They have claimed that full recognition of a species' worldview implies acceptance of a species-relative perspective. This relativism occasionally threatens to undermine the dominant poly-specieist ethics and has been repeatedly denounced as imperialist and as relying on a homocolonialist mentality. (Once again, cat advocates have been among the most vocal supporters of the relativist position, although they have at least implicitly accepted by the poly-specieist stance by refusing to leave the Parliament, whose workings they nevertheless obstruct on a relatively regular basis.)

The conflict of species worldviews is also well illustrated by the multiplicity of alternative models of (the same) ecosystems, and of the environment in general. From global models to hyperlocal ones, there is a large variety of competing models of the same spaces, relying on sometimes incompatible premises and assumptions. The Parliament has proposed and is currently funding a number of initiatives to define the basic principles for the integration of these models into broader, poly-specieist ones, aimed at resolving the seemingly irreconcilable tensions prevalent at the present time.

In conclusion, it seems that the all-pervasive egalitarian drive has amplified somewhat social antagonisms, this time on species-based lines. More than a few researchers believe this extends to science too, since the move towards perspectivism hampers integration, so much so that even inclusivist scientific advice is always countered based on *some other* perspective. Last but not least, there is a rising trend that advocates the recapturing of an enlightened human-centred outlook, claiming that it is inescapable anyway, and that the new egalitarian bureaucracy is simply pursuing factional interests under the guise of protecting some species or other.

6.3. Scenario 3: *We, the life*

Summary

In the third scenario, the aspirational paradigm of relation with nature is that of immersing and caring. Restraining the effects on the environment, as if humans were not part of it, is abandoned; as is trying to provide the space for negotiation among species, as if there was a need for an agora in the circle of life. Rather, humans become conscious and act as intrinsically responsible voices of Life. This involves going beyond dualism, beyond the separation between the human as an actant and the environment as something external and/or

objective. One philosophy that describes this position very well is that of biocentrism, as defined by Robert Lanza. Biocentrism states that reality is not independent of the observer, but very much created by it, and therefore that apparent consciousnesses are not intrinsically separated. Biocentrism with its non-dualist tenets is apparently at odds with common sense, and its adoption, beyond the assimilation of arguments in its favour, requires a shift in consciousness. In the third scenario, biocentrism becomes more and more common among scientists in physics, biology, or AI, who explore the paradoxes of consciousness and the source of life, usually in combination with more meditative or contemplative practices. A complementary influx includes scientists integrating nature related values from indigenous cultures. The biocentric scientists become respected voices in society, acknowledged sources of ethically grounded worldviews, influencing the design of socio-techno-environmental systems. These new stars of science often express themselves at the crossroads with art and spirituality, cultivating schools of thought and reflection, with the inherent wake of apprentices, followers, and contenders.

Key concepts: non-dualism, ethical grounded worldviews, VIP scientists

Biocentric scientists

In the third perspective, a new Copernican Revolution is underway: biocentrism establishes that reality is not independent of the observer, but very much created by it, and therefore that apparent consciousnesses are not intrinsically separated. The beings attaining this level of consciousness represent an acknowledged class of wisemen and women, able to promote principles for the design of human systems.

Backed by an interpretation of quantum theory, biocentrism posits that what we perceive as reality is a process that involves our consciousness, while the “universe” is simply the complete spatiotemporal logic of the self (Lanza, 2020). A similar concept, that of the “mental nature of reality” (Kastrup et al., 2019), draws mostly on the logical fallacies and internal contradictions of the reigning physicalist ontology and advances a compelling formulation of idealism that reconciles classical and quantum worlds.

The scientific formulations of biocentrism are on a convergence path with the naturalistic wisdom spread by renowned meditators: the concept the “inter-being” promoted by the Peace Nobelist Thich Nhat Hanh, or the concept of “interconnectedness”, advanced by Adyashanty.

The interplay of scientific understanding and experiential consciousness mutation is at the core of this new perspective, at odds with the reigning common sense, where reality is independent of us as observers, while we are separate entities among ourselves. That is why the new understanding, even while receiving strong support from science (e.g., quantum physics, cognitive science) has as yet not been widely adopted, but remains limited to a small but growing community. This community aims to embody the perspective and undergo a personal transformation. Its members train to be the top scientists of the future.

Science exists to bring clarity

One of the accepted social roles of this new type of scientist is to increase clarity and inspire people to the new ways of seeing. Their proposed models are worldviews, not just simplifications of reality (see, e.g., Fritjof Capra’s “world as a network”, or Daniel Wahl’s “regenerative cultures”).

However, this does not imply a convergence in the form of expression but, on the contrary, a diversification and a transgression of the disciplinary boundaries and of the borders separating pure science, engineering, arts, and even lifestyles.

The non-dualist truth is considered to be that of advancing towards the understanding of oneness. This may include forms of paradoxical thinking as triggers for a new understanding or as pointers to the limits of dualist perception.

Science is taken personally

Under the new paradigm, ideas are not totally disconnected from the proponent, similar to the way architectures reflect the architect. Therefore, the scientific message would be very often connected to the life of the scientist and her/his ethical and even aesthetic expression.

Ideas will be dynamic, given - on the one hand - the evolution of the promoter and of its supporters, and - on the other - the “evolutive information”. The latter requires us “to analyse the strong, resonant coupling between processes related to action and perception which emerges in the human brain” (Fiorini, 2019).

The dissemination of ideas relies greatly on mentorship, cascading face-to face or via online communities. Successful ideas are not actually replicated but transformed into new subjective ways of seeing.

The dialogue of paradigmatic ideas takes place in inspirational contests of the VIPs, with mutually agreed and evolving rules, in settings that recall the Glass Bead Game proposed in the 1931 novel by Herman Hesse, which has become one of the fundamental documents of the new perspective.

Biocentric by design

The decisions supported by this new generation of scientists are not so much the operational, immediate ones, but paradigmatic changes in the embedding systems (e.g., taxation, transport network, smart systems). Like in conceptual art, the proposed designs are ways of allowing the new flourishing dynamics of the ecosystems.

Neri Oxman coined the term, and pioneered the field of Material Ecology, which considers computation, fabrication, and the material itself as inseparable dimensions of design. In this approach, products and buildings are biologically informed and digitally engineered by, with and for, Nature (www.media.mit.edu)

Image source: Neri Oxman, Exhibition Material Ecology 2020, moma.org

Data is representation

In a biocentric view, data cannot be an objective representation, but the embedding of intention - “the ethics of qualitative research in a Big Data era is to foreground Big Data’s treatment of data as self-evident, and its positivist claim to represent the world innocently, accurately, and objectively, as matters of ethical concern” (Mauthner, 2019).

“Big Data ecosystemic framework [needs] to acknowledge technological progress and innovation as a complex player in the transformation of nature and its management, rather than simply either its abuser or its custodian. … What we need to come to terms with as a culture is that there is no equilibrium to return to” (Hogan, 2018).

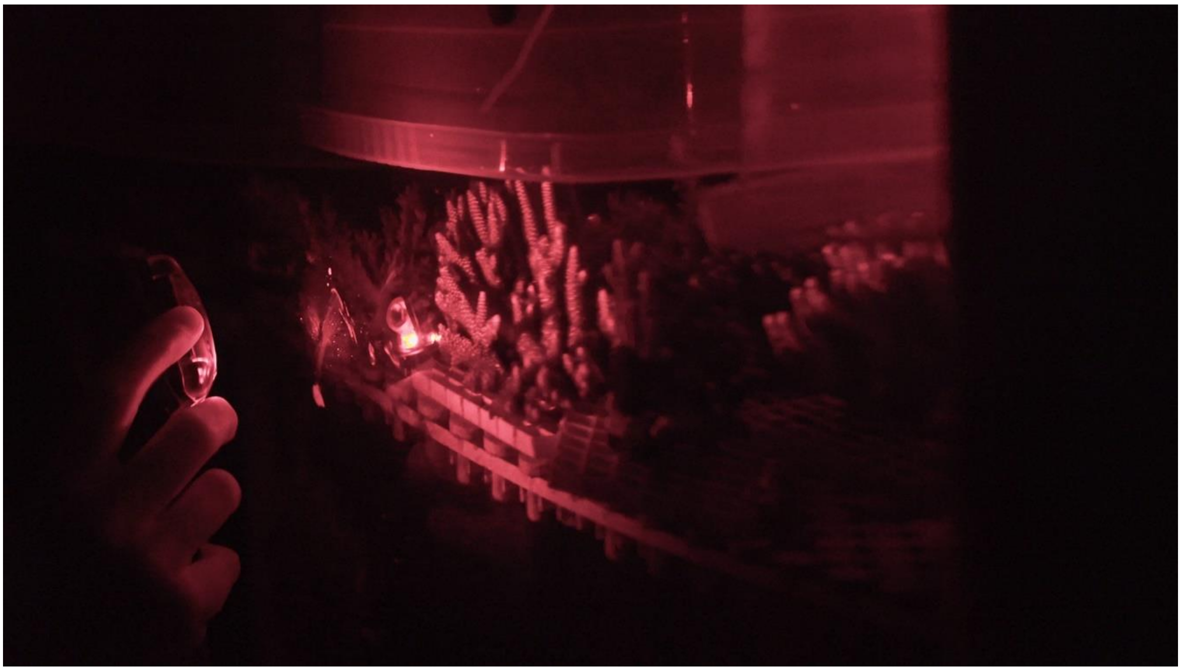
Dealing with complexity is not delving into its consuming granularities and intertwinings, but positioning from an integrative perspective, which implicitly makes room for open developments and reflexive adaptations.

Many of these developments integrate current scientific vocabularies and infrastructures, such as, for instance, the concept of Earth System Science (ESS), a transdisciplinary endeavour aimed at understanding the structure and functioning of the Earth as a complex, adaptive system (Steffen et al., 2020).

As such, the data collection and analysis systems are the most carefully designed by the top scientists.

Sonia Levy for the Love of Corals: An Ecology of Perhaps

“a case study of new paradigms for multispecies living, environmental conservation and natural history that are emerging in the wake of the Anthropocene. [...] a cinematic inquiry that focuses on the daily labour of caring for endangered beings to resuscitate them from their imminent human-induced extinction. The technology of the ad hoc laboratory; scientific knowledge; the complexity of marine ecologies; and the intimacy of providing care converge in the precision of sustaining coral IFV [in vitro fertilization]”



Source: www.sonialevy.net

In the quantum paradigm, there is a difference between automatic data collection and the information, which is actually perceived by the observers, as only the latter has consequences.

Data is fundamentally a tribute to dualism. However, the non-dual perspective does not antagonize the necessity of data collection or try to oversimplify it in an attempt of reduction but engages with data as mind artifacts and is preoccupied with its intentionality and the risk of the solidification of worldviews. This logic also applies to computer architectures, especially as they evolve into neuromorphic structures.

In an integration logic, big data is ultimately the sum of our perceptions, it is the Maya, the very fabric of illusion.

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