# TRAJECTS Topics

In a sustainable world, the energy and materials required to provide the fundamental bases for a life worth living for all people must contemplate the interlinkages with the surrounding non-human living world and respect the planetary boundaries within which life on Earth can flourish (IPCC, 2014, 2018). Over the past centuries, humanity has increasingly violated the planet's boundaries, heavily disrupting its natural cycles (Rockström et al., 2009, 2016). Not only are carbon emissions leading to a potentially catastrophic collapse of Earth's human-friendly climate, but other areas such as land use, freshwater withdrawals, nitrate or phosphate discharges, amongst others, are being put to such levels of stress, that not one but many of the fundamental cycles for life on this planet could be irreversibly altered over the course of the next decades (Raworth, 2017). As some suggest, the planet is already undergoing a mass extinction comparable to previous mass-extinction events (Kolbert, 2014).

This critical situation has spurred varied forms of research and debate around possible solutions and policy interventions required to correct the course of human's relationship with the environment. While traditional approaches favour market-based solutions to humanity's manifold social and environmental challenges (see for example Hepburn et al., 2020), more recently the field of *Sustainability Transitions Research* has emerged as a more ambitious and overarching alternative to conceive, understand and analyse the changes that must occur for humanity to steward the Nature it depends on (see for example Köhler et al., 2019; Markard et al., 2012). A more overarching approach and understanding of these issues is key not only to advance academic and scientific discussions, but perhaps more importantly, to better link academic research with the crucial ongoing discussions of practitioners and political decision-makers about climate, development and energy policy around the world.

Acknowledging the importance of this overarching approach and the dialogue between academia and practical approaches (e.g. policy/decision making and technical/social innovation), the partners behind the **Transnational Centre for Just Transitions in Energy, Climate & Sustainability (TRAJECTS)** have been making numerous scientific and practical contributions to sustainability transitions from multiple angles. We coincide in our shared interest on the different dimensions of two key transitions that must occur to mitigate the most important sources of greenhouse gas (GHG) emissions, as well as of other environmental impacts, to enable a pathway towards a more sustainable future.

The first transition is concerned with **the phase-out of fossil fuel extraction, transformation and use,** and constitutes a fundamental lever to effectively mitigate GHG emissions, and thus the climate crisis, since most emissions come from the combustion of fossil fuels (IPCC, 2014, 2018). Therefore, researchers affiliated for example to TU Berlin's CoalExit research group have tried to understand the key building blocks for a deliberate, just and well-planned coal phase-out (Auer et al., 2020; Brauers et al., 2020; Brauers & Oei, 2020; Oei et al., 2019; Stognief et al., 2019), colleagues in think-tanks like Agora, TU and FU Berlin have begun to analyze how fossil-based transportation can be replaced (Agora Energiewende, 2018; Agora Verkehrswende, 2017; Creutzig, 2016; Fritz-Thyssen-Stiftung & Freie Universität Berlin, 2020), and our partners in Colombia and South Africa - sometimes in cooperation with TU Berlin - have scrutinized the role of coal extraction, export or combustion in their countries, while reflecting on their contentious present and uncertain future (Burton et al., 2019; Burton, Caetano, et al., 2018; Burton, Lott, et al., 2018; Cardoso, 2015, 2018; Cardoso & Turhan, 2018; Oei & Mendelevitch, 2016, 2019; Spencer et al., 2018). We have thus followed the calls to understand, avoid and, if possible, overcome carbon lock-in (Unruh, 2000, 2002) in all its forms as a necessary condition for any effective fight against the climate crisis (Braunger & Hauenstein, 2020). Doing so, the partners behind this project have contributed to understand how a transition to a decarbonized energy system could eventually look (Löffler et al., 2017, 2019; Oei, Burandt, et al., 2020) and which implications it will have on people, communities and entire societies (Burton et al., 2019; Burton, Caetano, et al., 2018; Oei, Hermann, et al., 2020a, 2020b; Oei & Mendelevitch, 2019; Spencer et al., 2018; Strambo & Atteridge, 2018; Vishwanathan et al., 2018; Witajewski-Baltvilks et al., 2018). We work to provide further scientific bases to support the transition that the Global Energy System needs to undergo to become a fossil-fuel free system that balances the need for reliable, affordable and clean energy for all, within the planet's climate

and environmental boundaries, while manoeuvring today's global context of inequitable access to resources and high levels of poverty.

The second transition involves **the redefinition in the use of soil, the relationships with and between its inhabitants and the fundamental importance of protecting primary forests, promoting more sustainable agriculture and stopping and reversing ecosystem loss, particularly rainforests, savannahs, rivers and wetlands.** As the second highest source of GHG emissions and a key driver for ecosystem and biodiversity loss, this second dimension is essential, too. Amongst others, TRAJECTS' Colombian partners have aimed to provide increasing reflection on the strategic importance of ecosystems as vital as the High Andean *páramo* and how to shift paradigms as to how to steward and protect it (Buitrago, 2014). Further scholarship has provided holistic analyses looking at the deeply intertwined relationships between human occupation and use of land, ecosystem development and environmental protection (Alzate, 2008). Concerning the crucial role of changing paradigms when it comes to agriculture, UNAL has steadily positioned itself as one of the main research and teaching hubs on agroecology. Thus, much research has been devoted to understanding not only how to reduce the GHG emissions and environmental damages often associated with agriculture, but to provide information on how this activity can in fact become a sink to fix atmospheric carbon (León, 2009; León-Sicard et al., 2015, 2017). In Latin America, TRAJECTS' partners UNAL and UMS are also some of the leading institutions providing insights on how to protect key carbon sinks and biodiversity hotspots such as the Ciénaga Grande de Santa Marta (Ricaurte et al., 2019; Velez et al., 2018; Vilardy, 2015) or the Chocó rainforests (Montoya Arango et al., 2011). FU Berlin has initiated a research program on transition of food systems. By considering not only agricultural production, but also the value chain until food consumption, additional options for transformative change can be considered (Jacob & Ekins, 2020; Schrode et al., 2021).

Defining these two core research foci for TRAJECTS' work is thus oriented to address the major questions and challenges of initiating and accelerating some of the fundamental transitions required to sustain life on Earth and to protect our shared climate. Therefore, above all, TRAJECTS will contribute to **tackle the Sustainable Development Goals (SDGs) 13 (climate action) and 15 (protection of life on land)** by generating locally grounded yet globally minded knowledge on how to mitigate the main sources of GHG emissions, as well as of ecosystem decay and biodiversity loss, while contributing to shared prosperity and a life worth living. While this is the project's primary focus, TRAJECTS draws from a variety of inter- and transdisciplinary approaches, interests, and experiences. With them, it seeks to position itself to provide a distinctly holistic approach which can contribute to the fulfilment of SDGs 7 (affordable & clean energy), 8 (decent work and economic growth), 9 (industry, innovation, and infrastructure), 10 (reduced inequalities), 11 (sustainable cities & communities), 14 (life below water), and 17 (partnership for the goals).

Regarding the two aforementioned transitions, TRAJECTS' partners have been working at the interface between the **two socio-technical processes that lay at the core of any transition: innovation and exnovation**, as well as the synergies and trade-offs between these processes. Some of our research has been devoted to deliberately terminating or phasing-out unsustainable energy carriers, technologies, practices or policies (e.g. coal extraction and combustion), which is associated with exnovation (see David, 2018 or Heyen et al., 2017 on exnovation). While considerable research by our partners has been devoted to understand the risks of new coal investments (Cardoso & Turhan, 2018; Ireland & Burton, 2018; Merven et al., 2019), stranded assets (Burton et al., 2016; Löffler et al., 2019), coal phase-out (see for example Brauers, 2017; Brauers et al., 2018, 2020), as well as to identify the main drivers for coal persistence (Brauers & Oei, 2020; Corral-Montoya, forthcoming; Jakob et al., 2020) or the impacts of coal extraction (Cardoso, 2015, 2018; Marais et al., Forthcoming; Marais & de Lange, 2021), other pivotal dimensions of deliberate termination of fossil fuel use, transportation and extraction have been addressed, too (Fitzgerald et al., 2019; IEA, 2020b). This includes detailed labour market and economic diversification opportunities for coal exporters and especially regions (Burton et al., 2019; McCall et al., 2019; Okunlola et al., 2019), and broader questions of structural development of carbon-intensive developing economies (Altieri et al., 2016; Winkler & Marquand, 2009) to enable a just transition (ILO, 2015). While exnovation may be heavily concerned with the end of fossil fuel extraction

and use, it is by no means the only focus of deliberate termination of unsustainable practices. Among land-use or agriculture, for example, it is paramount to overcome monocultures (Altieri, 2009) and industrial cattle breeding, as well as the expansion in the world's agricultural frontier by cutting down primary forests (Willett et al., 2019).

On the innovation side, some of our respective work has been devoted to identifying, understanding or promoting more sustainable alternatives to current practices, for example decentralized renewables in the power system (López et al., 2019; McCall et al., 2019; Von Hirschhausen, 2017) or agroecology and agroforestry concerning land-use (León, 2009). Partners in South Africa have begun looking at the potential of fiber-rich, plant-based solutions to both replace materials from unsustainable mineral extraction and restore post-mining landscapes at the same time (Broadhurst et al., 2019; Harrison et al., 2019). In Colombia, we have already gathered experience on what communities at grassroots levels are doing to transform agriculture, energy supply and forestry, amongst others (Cardoso, forthcoming.; Santamaria et al., 2021). Within TRAJECTS' networks important efforts also beyond Colombia and South-Africa have supported more sustainable alternatives in decentralized "swarm" electrification in Bangladesh based on peer-to-peer modeling (Kirchhoff & Strunz, 2019; Dumitrescu et al., 2020), large-scale dissemination of decentralized stand-alone solar systems in Bangladesh and Kenya (Heinemann et al., 2019; Hirschhausen et al., 2020) as well as disruptive smart data and mobility concepts in urban areas (Ustun et al., 2019).

As Figure 1 shows, while the research, debate and learning that TRAJECTS aims to encourage will focus on climate change mitigation in the two focus areas of fossil-fuel phase-out and changes in land management and ecosystem protection, it will produce demand- and policy-oriented research and teaching on the two principal processes of socio-technical transitions (exnovation & innovation). TRAJECTS hereby draws on the integrative approach, explained in more detail in the following section (and depicted in Figure 2).

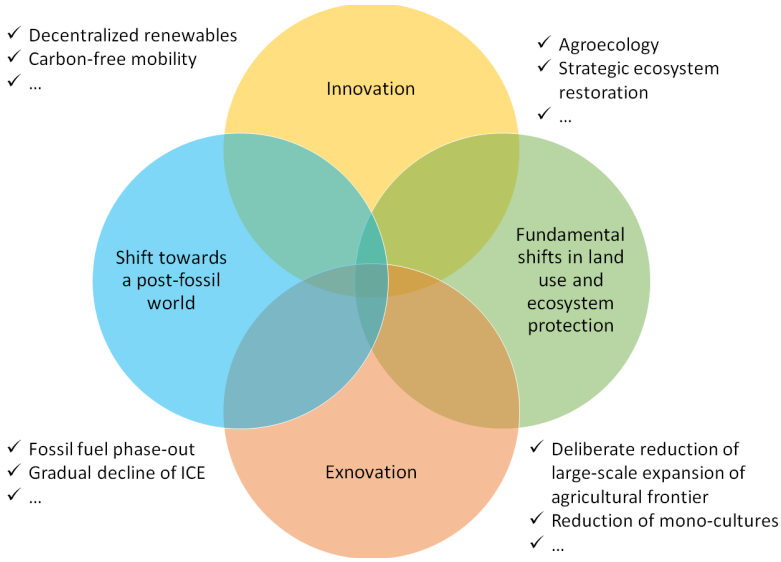


*Figure 1: TRAJECTS' research focus combines the shift towards a post-fossil world with fundamental shifts in land use and ecosystem protection.*

One example of working at the interface of exnovation and innovation in sustainability transitions relates to the energy system. There, our work has allowed us to observe that while renewable energy technologies such as solar or wind power have been continuously becoming cheaper and their deployment has boomed over the past two decades (IEA, 2020a; REN 21, 2019), this has not yet been complemented by a global phase-out of carbon-intensive technologies (Hirth & Steckel, 2016; Steckel et al., 2015). In some countries, in particular emerging economies, a carbonization of the energy supply is still ongoing and it is still unclear if it might accelerate in the aftermath of the COVID-19 pandemic (Arango-Aramburo et al., 2020; Edenhofer et al., 2018; Yanguas-Parra et al., forthcoming).

A different dimension is concerned with the fast decline of European fossil fuel imports (in particular coal), which is posing serious **challenges for energy-export oriented economies** (like South Africa and Colombia) that have relied historically on raw exports of fossil fuels (Oei & Mendelevitch, 2019; Yanguas-Parra et al., forthcoming). This touches upon what has been termed “supply-side” climate policies (Lazarus et al., 2015; Mendelevitch, 2018), which requires both dealing with the deliberate decline of fossil fuel extraction (Muttitt et al., 2016; Rosenbloom & Rinscheid, 2020), as well as finding alternatives for people and affected regions to maintain and in many cases improve their standard of living (Hanna et al., 2020; Marais & de Lange, 2021; Santamaria et al., 2021). This rapid decline of fossil fuel exports has similarities with some of the challenges that European fossil-extracting regions faced in the last century, when fossil fuel extraction declined in their jurisdictions (switching to cheaper imports due to rising globalization) (Caldecott et al., 2017; Oei et al., 2019). At the same time, countries in the Global North that have historically profited from cheap energy imports from the Global South may have a historic responsibility to share the burden of a just transition (Bejarano-Barrera, 2001; Perry, 2020).

A final example of the work at the interface between exnovation and innovation is the debate on the concept of "**service provisioning systems**", which emphasize that there are different configurations of how physical and social underpinnings of wellbeing are satisfied, but that some are required with high energy demand and others with low energy demand (Brand-Correa et al., 2018). For example, vehicles based on electric energy can deliver similar mobility services (Ahjum et al., 2018), even as primary energy required is a factor three to four lower than for conventional internal combustion engine (ICE) cars (Hill et al., 2019). **Good urban planning can enable short distance access to education, jobs, and health, and by making streets safe, enable healthy active mobility** (Newman & Kenworthy, 2006). Restaurants can offer healthy low-carbon diets, fulfilling long-term intrinsic preferences (Ensaff, 2021). Such solutions are attractive, because they directly focus on what people want and need, and can often be achieved with limited funds because it simply requires a shift in regulation and physical space dedications. They also need tight integration with shifting energy supply systems characterized by intermittent renewables, novel jobs, and novel requirements for energy system management and storage technologies. The realization of solutions in this emerging opportunity space is intellectually exciting but more importantly can deliver solutions quickly (Creutzig et al., 2018). Important, too, is that countries in the Global South have vastly more experience in low-energy service provisioning systems, some of them functioning very well, such as smart phone based direct marketing of local agricultural produce to urban demand. Thus, the envisaged TRAJECTS centre would enable a multi-directional learning opportunity, where experience and solutions from Global South partners enter in dialogue with those of Global North partners.

Therefore, a further contribution that **TRAJECTS seeks to make is to promote academic and extra-academic exchange initially triggered by, but not restricted to, Energy System Transition, for example between European countries such as Germany, and countries in the Global South such as Colombia or South Africa.** While North-South exchange could inspire solutions in developing and emerging economies - and prevent economic hardships and social disruptions -, we recognize that at the same time, **policy innovation taking place in emerging countries, especially in the field of linking social and environmental issues, is an area from which discussions in the Global North could benefit.** A prominent example of this is the initiative by the movement *La Via Campesina* to “collectively cool down the planet” by supporting small-scale, food producing farmers in their endeavour to attain food sovereignty (GRAIN & Vía Campesina n. d.). Another case which has been studied in Colombia has to do with the fundamental role that peasants and ethnic minorities have in protecting strategic ecosystems, while remaining, subsisting and even thriving on-site (Betancourt et al. 2017). South-North exchange on the more sustainable behaviour and consumption patterns, for example from ancestral communities, is also pivotal for global sustainability solutions to emerge (Montoya Arango et al., 2011).

Recognizing the fact that countries in the Global North are disproportionately responsible for historical GHG emissions and currently have much higher ecological footprints than their peers in the South, TRAJECTS seeks to offer a dialogue, research, teaching and action platform that helps countries in the Global South to avoid following the same path as their North peers with the catastrophic global

consequences that may entail. At the same time, it **aims to articulate South-South exchange to discuss similarities and differences in the countries joining the network**, which have contexts (and problems, and possibilities) more similar to each other than is the case with partners in the Global North. Partners in the Global South often confront challenges that are transversal such as endemic poverty, violence, inequality or corruption, and sometimes relate to the (shared) legacy of colonialism. Within this context, TRAJECTS aims to strengthen existing and open up new avenues for exchange and cooperation between Global North countries that have been historically carbon-intensive and are slowly accelerating the pace of transitions beyond fossil fuels, and Global South countries which have historically delivered much of the raw fossil energy carriers and could still avoid further carbon lock-in, leapfrogging a carbon-intensive development pathway. **Such transitions to clean, reliable and affordable energy mixes should aim to avoid the mistakes of past transitions and correspond to the scale and speed required by current global environmental and social challenges.**

**Focusing on these complex dynamics and huge opportunities, TRAJECTS will support and strengthen transcontinental exchange, research & education on transitions towards a sustainable future.**

Living in a semi-closed, dynamic complex system such as planet Earth, caution is nevertheless warranted: humanity is compelled not to see every aspect in isolation. If only one dimension, for example the climate, is dealt with obviating all other dimensions, not only the sustainability or the efficiency but also the fundamental effectiveness of a "solution" may be compromised. Water dams, for example, usually presented as the alternative to accelerate an energy transition, are too often deployed without considering associated losses of forest cover, biodiversity, crop lands, amongst others (Temper et al., 2020; Ulloa & Romero-Toledo, 2018). This makes it highly questionable whether they will contribute to more sustainability (Robles (ed.), 2021). Another example is the use of biomass to manufacture biofuels and "decarbonize" the transportation sector, or its inclusion as a component of seemingly attractive power system fixes such as bioenergy with carbon capture and storage (BECCS). While using biomass may in fact reduce some GHG emissions, it necessarily requires vast amounts of land or water, and is often associated with losses in biodiversity and land-use conflicts with food production, amongst others. A different example is the increasing discussion on wind turbine placements and reduced level of public acceptance in Germany (Krekel & Zerrahn, 2017).

As these examples show, it is key to connect all relevant variables in both the natural, the economic and social systems, if false solutions are to be avoided and genuine sustainability attained. Therefore**, beyond a traditional energy-system transition perspective, we aim to broaden the perspectives to include the climate-biodiversity-society nexus, which is essential to understand impacts, problems and potential local solutions for truly sustainable transitions**. As Figure 2 shows, TRAJECTS aims to enable an integrative approach that transcends boundaries of discipline, geography, and methodology.

**The first fundamental pillars of TRAJECTS' integrative approach concerns society. This pillar is concerned with the economic, social, cultural and political struggles and debates associated with these Transitions to Sustainability, and the people** inhabiting the areas in which energy, mining or land use occur. If people's perspectives, experiences and preferences are not taken into account in "just" transition processes, acceptance rates are likely to drop and people, more often than not, will resist, as many currently do, to external and illegitimate interventions (Temper et al., 2020). In that case, the intended "solution" may not be able to continue indefinitely, sometimes being politically infeasible, and therefore the very definition of unsustainable.

**A second pillar is concerned with the role of protecting and enhancing biodiversity.** This relates to restoring crucial structural aspects of historically intervened ecosystems, as well as learning how to avoid destroying untouched ones to promote the highest possible diversity of life on land and below water. Ecosystem restoration and even rewilding have for example been linked to potential action strategies to deal with post-fossil landscapes that will start becoming a locus of environmental action as fossil fuels are phased out (Harrison et al., 2019). Both in former fossil fuel extraction areas, as well as

in degraded areas previously dedicated to monocultures or cattle ranching, ecosystem restoration can become a key lever to accelerate carbon capture and storage - in the soil and the biomass of slowly recovering ecosystems (Broadhurst, Chimbganda & Hangone, 2019), while opening up large spaces for biodiversity and nature to re-flourish.

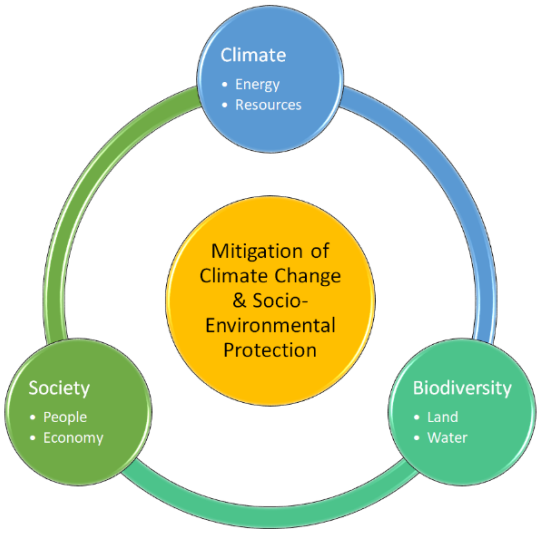


*Figure 2: TRAJECTS' way of working targets the Nexus between Climate, Biodiversity and Society.*

**The third pillar deals with the study of the different sources of GHG emissions and role of strategic (land-based) ecosystems as huge carbon sinks that are currently in peril.** Energy system transition and the switch to 100 % renewable energies is a fundamental lever to decarbonize the atmosphere (Bogdanov et al., 2019; Jacobson et al., 2017). At the same time, ecosystem protection and restoration can play a pivotal role to re-carbonize the soil. Not stopping or even reversing the accelerating loss of ecosystems such as the Amazon rainforest, will release huge amounts of carbon into the atmosphere. Engaging in a trans- and interdisciplinary exercise of research & education, it is key to highlight the role of changing existing approaches to land management and planning, in order to propose bold solutions to increase ecosystem restoration and improve the stewardship of natural patrimony (Aguilar-Garavito & Ramírez-Hernández, 2016).

Furthermore, long lasting experiences from exchanges with local communities, for instance in coal regions (Santamaria, Cardoso & Caselles, 2021), show that **while the challenges and its drivers are of global scale, the complexity of these issues and the ways in which countries and human groups are affected by them are locally specific and differ according to the local circumstances. Hence, local answers and perspectives are paramount**. For countries in the Global South, this represents a double challenge: while succeeding in a transition towards sustainability and achieving their SDGs is key to steward the material and social bases for the future, to achieve these transitions, manyfold socio-economic, political, and institutional challenges, such as poverty, corruption or violence must be tackled (Bertram et al., 2018; Lamb & Minx, 2020). This is the fundamental basis to understand the central role that social scientists are expected to take in TRAJECTS activities.

Therefore, **we aim to offer global analyses resulting from transcontinental research cooperation on solutions for these challenges, while integrating local insights by academic, as well as partners beyond the academic sphere** in civil society, grassroots initiatives, businesses, and public administration, amongst others, throughout the entire research process, **starting with a co-creation and adjustment of targeted research questions**. This knowledge exchange can enrich all partners, while producing meaningful, viable and legitimized reflections and recommendations, which are another key contribution of TRAJECTS, responding to the challenges and opportunities of countries in the Global-South for achieving the SDGs (in particular SDG 7, 8, 9, 10, 11, 13, 14, 15, and 17).