# Case for support

## Title

BRIDGE - Building Resilience In a Dynamic Global Economy: Complexity across scales in the Brazilian Food-Water-Energy Nexus

## Aims and objectives

- To develop a framework of analysis and policy engagement to effectively inform and support the policy cycle in Brazil to reach objectives of sustainable development in a context of global environmental and economic change.
- To engage with the policy process and cycle to determine the role of appropriate policy instruments and how they can be best implemented, to improve resilience of the food-water-energy nexus in Brazil to global environmental and economic change.
- To transfer analysis skills, technology and knowledge between the UK and Brazilian academic and policy communities to effectively inform and guide a continued sustainability transition.
- To jointly develop a new methodology to assess the cross-sectoral complexity and uncertainty involved in the food-water-energy nexus across scales, for Brazil in a context of global environmental and economic change.
- To jointly develop robust quantitative evidence and novel research tools and methods embedded in highly detailed new generation computational models, which will be made available to researchers in academia, industry, civil society and government, in both the UK and Brazil.
- To carry out successful demonstration of sustainability projects on the ground in Santa Catarina with key sectoral and regional policy institutions and networks whose activities impact on and have influence over the nexus challenges.

## Research questions being addressed and methods for analysis

### *The complexity in the Food-Water-Energy nexus in Brazil*

Energy, water and food production and consumption in Brazil face important challenges. River flows and water reservoirs, including in dams, have record low levels and face scarcity, requiring curtailing a predominantly hydro-oriented electricity system (e.g. Watts, 2015). The productivity of the land in many regions is likely to change excessively with climate change due to significant expected changes in rainfall (Phillips et al., 2009), affecting the viability of agricultural practices in the affected areas. The Brazilian economy is highly focused towards exporting agricultural products and food, with one of the highest shares of agricultural exports in the world (Figure 1), which makes it vulnerable to global economic changes. The profitability of some types of agricultural production, for instance meat and soya, is likely to evolve with the accelerated or fluctuating growth of consumption in several nations around the globe, which may incentivise excessive indirect land-use changes (Arima et al., 2006) and environmental degradation (e.g. Tollefson, 2015). Increasing land productivity is possible (Strassburg et al., 2014), but will not necessarily happen without policy intervention. These critical issues are tied to one another through the complex Food-Water-Energy (FWE) nexus. Understanding the nexus is key to sensible planning for improving the resilience of the Brazilian economy and environment to internal and global environmental and socioeconomic change.

The FWE nexus is a complex system involving many interactions between social and natural components, of which the emergent properties are not well understood. Effectively, it is not understood, for instance, whether food price fluctuations are related or not with events taking place in the energy sector (e.g. the oil price or increasing biofuel demand). Also, the extent to which the Brazilian economy and environment could be affected by food consumption patterns in other emerging nations has not been quantified. Furthermore, Brazil is known to be susceptible to significant environmental change in scenarios of climate change (e.g. RCP8.5 in IPCC, 2013), especially when combined with deforestation (Davidson et al., 2012) which will inevitably affect its ability to produce agricultural commodities, labour employment in the agricultural sector, regional economic development and ultimately national growth and efforts towards poverty reduction.

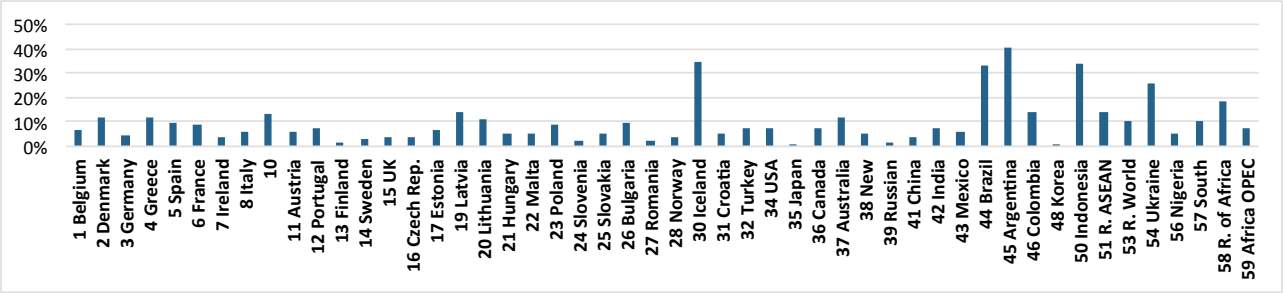



Figure 1: Current share of total exports made of agricultural products and food globally (33% for Brazil).

A sustainability transition in the FWE nexus involves improving resilience of all of its components, which include land-use, trade, energy production and water management. Understanding the science of these connections is not enough, however, because changes of policy, legal frameworks and regulatory compliance act to influence and re-orient the system in subtle interrelated ways. Such changes, however, need to be extremely well informed by science in order not to lead to unintended consequences (e.g. generating energy poverty with emissions reduction policy, barring access to water with pricing policies, destruction of ecosystems due to land policy for creating jobs, etc). Thus, qualified multi- and trans-disciplinary analytical capacity can become crucial for informing effective policy-making and environmental law.

*In this project, we wish to address the following questions*:

1. How will global environmental change affect the Brazilian Food-Water-Energy nexus? What are the potential impacts of ensuing water scarcity and land use change on the Brazilian food-water-energy nexus?
2. In which directions will the current trends of global economic change likely lead the Brazilian food-water-energy nexus in 2050 and beyond? What are the socioeconomic implications for Brazil, and how are they connected to the food-water-energy nexus at different scales?
3. Which portfolios of policies, at local, regional and state level, can most effectively incentivise the sustainable development of Brazil, and improve its resilience to the challenges of the food-water-energy nexus?
4. What projects, at the community level, can contribute to improving the resilience of the Energy-Water-Food nexus in Brazil?

*In order to answer these questions, we propose the methodology, lying at and beyond state-of-the-art research in the field, detailed in the following sections.*

### *Modelling agent behaviour in the nexus*

Current state of the art global computational models struggle to describe the complex interactions involved in the FWE nexus (e.g. Arneth, et al., 2014; Rounsevell et al., 2014). This is due to a lack of representation of behavioural science and knowledge at the decision-maker level (e.g. consumer, farmer, investor). This limitation prevents the models from realistically exploring problems involving agent response to incentives including policy, for instance problems of land-use change induced by price variations, (as in Morton et al., 2006), which form one of the key drivers of unsustainable land management and use of resources. In essence, the response to incentives by agents responsible for land-use decisions is a question of behavioural economics, to model decision-making by interacting heterogeneous agents under expectations of profits, not treated explicitly in contemporary models (Arneth et al., 2014; Rounsevell et al., 2014). Research in behavioural science exists that can be incorporated in models to overcome these limitations and unleash insight for FWE nexus management, but this remains to be done.

Contemporary analyses rely on either systems optimisation principles, or assume identical agents with perfect information responding instantaneously to drivers. Models are effectively designed to tell which allocations of resources (e.g. land, capital) maximise production levels given certain constraints. This, however, does not address the question as to what would be the real-world outcome of introducing specific new FWE policies, such as taxes on commodity prices or land-use regulations and subsidies, due to not addressing realistic agent behaviour response (Arneth et al., 2014). These difficulties are beginning to be overcome in new-generation models that simulate decision-making by interacting heterogeneous agents, designed specifically to address policy


Figure 2: Information flow diagram across scales, from global to local.

change, but existing models cannot be applied at the global scale of analysis necessary for countries heavily reliant on global trade. The most realistic approaches use Agent-Based models (ABMs), with explicitly defined heterogeneous agents and interactions (Arneth et al., 2014). But the same result can equally be achieved using non-linear dynamical equations and statistical models representing the same in aggregate. This is faster to calculate on a computer, and can therefore be readily scaled up to a global analysis, difficult to achieve with ABMs (see Mercure et al, 2014).

Brazil is not an isolated country: the fate of its economy and environment is closely tied to activity in the rest of the World (in particular for food consumption, see Figure 1). Understanding the FWE nexus in Brazil critically requires analysing Brazil in the context of global economic and environmental change (Figure 2). To this end, we will develop a highly detailed new generation computational model of coupled land-use, energy use, water use and macroeconomics for Brazil in the global context, based on econometric and behavioural modelling coupled to natural systems. The UK has a long track record and tradition of climate, environmental and economic modelling; thus this project will be based on existing established UK expertise. This builds upon existing work and capacity at the University of Cambridge (UCAM), Cambridge Econometrics Ltd (CE) and The Open University (OU), using the global macroeconometric model E3ME (CE), coupled to the model of choice, adoption and diffusion of innovations and practices FTT (UCAM) and emulators of large biophysical models for climate change, the carbon cycle and the land cover (OU).

E3ME (www.e3me.com) is a well established global non-equilibrium macroeconometric model developed and maintained at CE. It is frequently used by the European Commission for Impact Assessment of environmental policy, including the assessment of the 2030 climate and energy targets and other policy analyses (Barker et al. 2015; Pollitt et al. 2014, 2015). The most recent version of the model has been applied in Latin America as part of the CLIMACAP research project. It features a treatment of material flows in bilateral trade, including agricultural commodities using FAO data. With this it can project scenarios of global consumption of these products in 59 regions, but also crucially, it can determine how changes in prices somewhere will be accommodated by either substitution between commodities or changes in trade patterns elsewhere, enabling, with the models below, to explore land displacement effects, one of very few frameworks that can do so.

FTT is a dedicated general model of business or consumption decision-making by heterogeneous agents under expectations (e.g. of price or return on investment, Mercure, 2012, 2015; Mercure et al., 2014). It has been applied to agriculture in a recent pilot project, theoretically and computationally. Coupled to state of the art land cover and productivity modelling, as well as climate science and carbon cycle modelling (expertise of the OU, Holden et al., 2014; Oyebamiji et al., 2014), FTT:Agriculture is designed to explore land-use change decisions based on expectations over local agricultural commodity price contexts. Its real scientific power however is unleashed when coupled to E3ME. This enables us to explore land-use changes that result from agricultural commodity price fluctuations, which themselves stem from the evolution of consumption in countries across the world, land productivity and scarcity. In this model context, price and return expectations by heterogeneous agents lead to large-scale land-use change. For instance, we can simulate the impact of rapidly increasing meat consumption in middle-income countries, due to increasing affluence, on deforestation in Brazil. E3ME-FTT includes the capacity to model future global energy system and fuel use emissions, while OU emulators provide detailed projections of climate, warming and rainfall changes on a global spatial grid for input to GIS tools.

The incorporation of heterogeneous agents and their expectations provides the opportunity to include representations of many types of policy instruments, individually or in combination. This

includes energy sector policies such as technology support policies, regulations and market pricing policies (taxes, carbon pricing etc). Here, FTT:Agriculture will allow representation of land use regulations and commodity pricing policies (tariffs, taxes, etc), as incentives to heterogeneous land-use agents. This new cutting-edge type of non-equilibrium/non-optimisation modelling capacity with high policy instrument definition does not currently exist elsewhere in the international community. The project will thus create a new-generation global land-use modelling framework that could help inform land-use policy internationally, with a specific focus on Brazil.

### *Bridging science and policy: supporting the policy-cycle in Brazil*

A sustainability transition in the FWE nexus takes place within an appropriate policy context. Policy-makers, however, have constraints of their own, and it is crucial that any scientific information produced with the aim to influence the policy process be fed correctly into the policy cycle with clear understanding of its legal and political requirements and implications, in order to have a clear chance of success. This demands specialist knowledge of policy contexts and of environmental law (e.g. Vinuales, 2012). Furthermore, understanding the policy cycle in its context requires knowledge of the specific location and culture in which it takes place, requiring the involvement of *local experts and contextual knowledge in environmental policy and law*.

A scientific impact assessment of policy options from a modelling perspective is highly valuable to policy-makers when it is able to obtain information about the effectiveness of policy at influencing decision-making by consumers, investors, farmers and other agents. Effectively, valuable insights can be obtained this way: in the climate change policy area, time being limited, significant value lies with any ability to predict the effectiveness of emissions reduction measures, especially when their costs and legal/political feasibility are known in advance.

In this context, marrying complex modelling of high policy resolution with specific expertise in environmental policy and law proves to be the best science-advising work structure. Policy experts then determine, in close collaboration with local policy-makers, which policies could have a chance of success in the local policy cycle, testing these through the impact assessment modelling expertise, and feeding information back to the policy-maker in an iterative manner.

We have already assembled such an expertise through an extension of our current EPSRC-CONFAP energy-water-food nexus networking grant (PI: **J.-F. Mercure** [**JFM**], grant no EP/N002504/1, http://gow.epsrc.ac.uk/NGBOViewGrant.aspx?GrantRef=EP/N002504/1). This includes experts in environmental law (the C-EENRG centre, UCAM, led by **J. Vinuales**, [**JV]**), environmental policy impact assessment modelling (previous section, UCAM, led by **JFM**, CE, led by **H. Pollitt** [**HP**], and OU led by **N. R. Edwards** [**NRE**]) and academics in Brazil involved in the local policy process with detailed knowledge of the Brazilian context, with established experience of local policy and public engagement (UNISUL, led by **B. Guerra** [**BG**]).

We propose to engage policy-makers in Brazil through the involvement of experts in environmental law and policy (**JV**), modellers (**JFM, HP**) and Brazilian academics with extensive experience in successful policy engagement and sustainability projects (**BG**). This will involve raising awareness about the socioeconomic and environmental challenges associated to the FWE nexus, and supporting the regional dialogue of key public and private actors and decision-makers in this field in Brazil. It will also provide support for capacity-building and knowledge-sharing for environmental policy assessment with analysis of legal and governance contexts. The project will examine actual and prospective environmental policies for Brazil at the state level, facilitated through close collaboration with local experts with insights into the local challenges and opportunities.

Policy processes are complex and rarely linear, and simply presenting information to policy-makers and expecting them to act upon it is very unlikely to work. On the contrary, showing that policy 'works' as part of the policy formulation process, improves the chances of success of policy implementation at various levels. For that reason, and building on previous successful experience (REGSA, JELARE), this project will involve setting up real small-scale sustainability demonstration and awareness raising projects in Brazil in order to show best-practice in each case and engage with the public. This will include a 'sustainable forest' project related to farming practices at the UNISUL university farm, an 'energy forest' project related to the generation of sustainable forestry-related energy products, and a 'less hydro' simulation exercise to engage the public in understanding how to increase the resilience of the energy system to water scarcity.

## Expected research results for both academic and potential users

### *Expected results and academic beneficiaries internationally*

The modelling part of this project will open new perspectives on environmental policy assessment that can be replicated by researchers of the international community for other purposes, in different national or international contexts. In particular, this will enable a new set of questions to be analysed: indirect land-use change, agricultural commodity price bubbles, land scarcity that results from environmental and economic drivers across the globe. Furthermore, it will offer a higher definition of market and non-market policy instruments, in all areas of the FWE nexus (e.g. land, trade, carbon pricing, electricity, transport, fuel-use, emissions), than most current state-of-the-art models, broadening perspectives of environmental policy analysts. By making the methodology open-access, with online documentation, and deploying an intensive programme of dissemination, the methodology could be replicated by other academics and policy analysts internationally.

### *Transferring skills, technology and knowledge to the broader Brazilian academic and policy community for a continued sustainability transition*

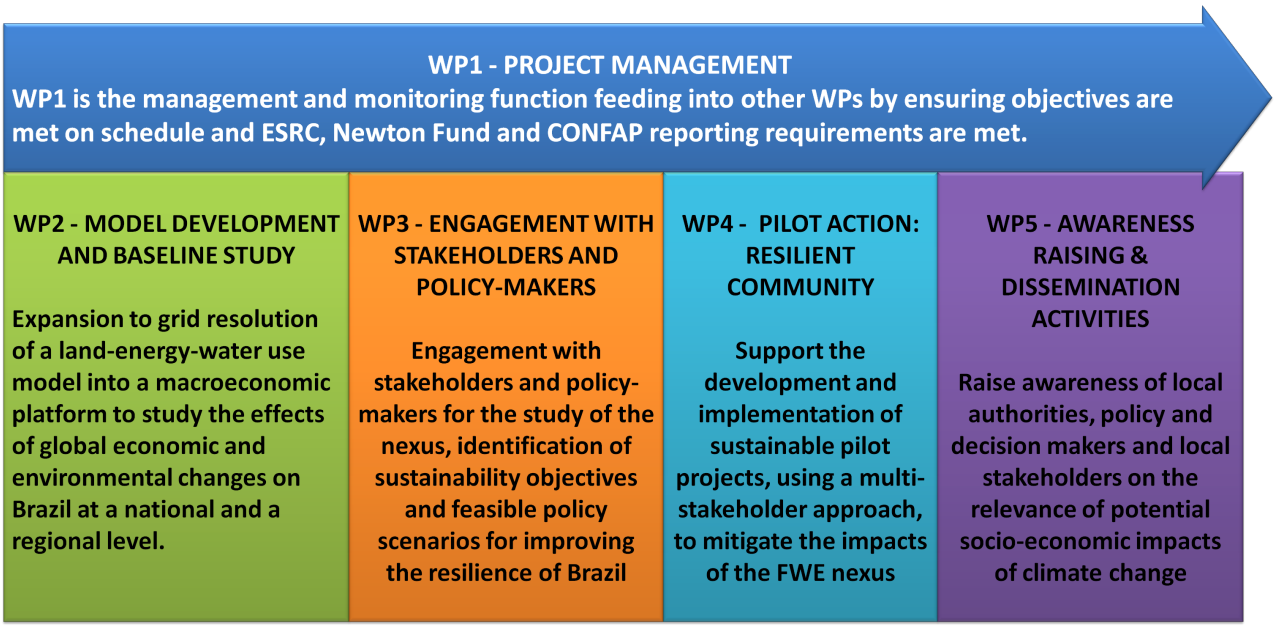
A sustainability policy research project is useful when it successfully delivers viable policy options that can promote a sustainability transition; however, it is much more likely to generate a transition if it aims at transferring the appropriate skills and knowledge for policy impact assessment beyond the end of the funded period. This, therefore, demands a detailed effort at training, disseminating and teaching skills developed in state-of-the-art internationally recognised UK research institutions, for analytical capacity building in Brazil, from both an academic and a consultancy perspective. This does not mean that analytical capacity is not available in Brazilian institutions; however there is insufficient capacity to fully understand and address the scale of complexity of global and Brazilian sustainability issues. The project will therefore contribute to build the Brazilian capacity for, and empower its own expansion at, analysing the impact of potential policy packages in order to guide policy-making through a sustainability transition during the coming decades.

In this context, this project will carry out a detailed programme of skills transfer and capacity building that will take place through UNISUL with Brazilian partners. Significant training capacity and experience is available at CE for use of the E3ME-FTT framework, which has been used in numerous projects, and which has resulted in successful energy-environmental policy analyses in different contexts internationally (e.g. East Asia, Lee, Park, & Pollitt, 2015; Europe, Sijm et al., 2014). We will complement this with additional training sessions for the use of statistical emulators, and sessions on key environmental law and policy information concerning how to get involved in the policy cycle. The typical hands-on approach of CE for training on modelling will be adopted and generalised. This training will be made available to project staff as well as stakeholders.

Participant actors in the project will be able to:

1. Understand, in depth, sustainability issues in Brazil and worldwide, especially energy security, food security (agriculture) and water security Nexus throughout the Brazilian territory;
2. Understand the causal relationship between environmental and economic change in the world and their effects in Brazil, within the NEXUS perspective;
3. Assess qualitatively and quantitatively the current and future policies for a sustainability transition;
4. Justify consistently before the government and business officials the need to update and redefine sustainability policies in Brazil;
5. Disseminate to and engage government, business leaders and society at large on the observation of sustainability policies of Brazil and the need for informed decision-making;
6. Understand the operation of computer tools used by UCAM-CE-OU in the modelling of sustainability policy scenarios;
7. Conduct of future scenarios simulations of environmental and economic change in Brazil, using the work and the existing scientific capacity from UCAM-CE-OU through the macro-econometric model E3ME and the FTT model;
8. Raise awareness to the population at large of the need to monitor climate changes that are occurring in Brazil and in the world in the NEXUS context of energy security, food security (agriculture) and water security throughout the Brazilian territory

## BRIDGE Project implementation: the UCAM-CE-OU-UNISUL partnership




**WP1. Project management:**
WP Leader: UCAM. Schedule: Month 1 - 36

**WP1 Objectives**: WP1 is the management and monitoring function feeding into other WPs by ensuring objectives are met on schedule and ESRC, Newton Fund and CONFAP reporting requirements are met. University of Cambridge (UCAM) will be responsible for the overall project coordination and management, administration and reporting although all partners will input into this package. Within the partnership, progress will be guided by the Project Steering Group and regular contact will be maintained via e-mail, telephone, video conferencing and project meetings.

**Roles of Partners in WP1:** UCAM will lead WP1, although all partners will input into this package.

**1.1 Establish a Project Steering Group and management board.** Months 1-2. UCAM-UNISUL.

**Description:** Immediately after the start date of the project, the coordinator (UCAM) will organise the kick-off meeting during which a Project Steering Group (PSG) will be established to consist of one member of each partner organisation. The tasks of the PSG will be: set up a detailed action plan, agree on Logical Framework (Objectively Verifiable Indicators, OVIs), outputs and management activities. The PSG will agree the rights and obligations of all partners, the rules of cooperation, and measures in case tasks overrun, particularly those that affect other WPs.

**Outputs:** 1 Kick-off meeting, project steering group and management structure implemented.

**1.2 Organise Project Steering Group and regular meetings**. Months 1- 36. UCAM-UNISUL.

**Description:** 6 project meetings, always combined with Project Steering Group (PSG) sessions, will be organised in order to evaluate the project's progress. The meetings will be held alternately in the U.K. and Brazil. A final meeting will be held to conclude the project.

**Outputs:** 6 project management meetings, including PSG sessions.

**1.3 Project evaluation and regular reporting**. Months 6-36. UCAM-UNISUL

**Description:** Project progress will be monitored and evaluated regularly on the basis of the agreed OVIs. Quarterly financial and expenditure reports will be requested from the partners by UCAM. Progress will be evaluated at the regular PSG meetings. UCAM will coordinate and gather input from all partners for the interim technical and financial reports and report these as required to RCUK and CONFAP. UCAM will coordinate the compilation of a final report, consolidating project results and summarizing the achievements of the project. The PI will ensure the Project Outputs are uploaded as required by the ESRC on Researchfish. To evaluate the success of engagement activities, feedback will be gathered from the target groups or participants of the project activities e.g. key actors in pilot action communities, visitors to the websites.

**Outputs:** 2 interim project reports, 1 final meeting and 1 final report.

**WP2. Model development and baseline study**
WP Leader: J.-F. Mercure, UCAM. Schedule: Months 1 - 24

**WP2 Objectives**: Expansion to grid resolution of a land-energy-water use model, FTT:Agriculture, and its integration with the E3ME macroeconomic platform to study the effects of global economic and environmental changes on Brazil at a national and a regional level. The proposed integrated modelling platform will be based on existing established UK expertise in environmental and economic modelling.

**Roles of Partners in WP1:** UCAM will lead WP2, will develop the E3ME-FTT modelling platform for analysis and the baseline scenario, in close collaboration with CE and OU.

**2.1 Incorporate socio-economic factors in FTT:Agriculture and integrate it into the macroeconomic platform E3ME-FTT**. Months 2-24. UCAM

**Description:** In this WP, we will scale up an existing successful model concept, FTT:Agriculture, to study the demand for and bilateral trade of agricultural commodities, and determine what farming and land allocation decision-making are taken to supply this demand globally in 53 economic/geographical regions. FTT:Agriculture will be developed with higher definition on a GIS grid and integrated to the macroeconomic platform E3ME. The composite model suite will be able to analyse land-energy-water use scenarios for Brazil (and 58 other world regions). The platform will enable to explore the consequences of global economic development, global environmental change and of trade and land-use management policy to the allocation of land, the level of land-use change and land-use emissions. At the same time, the platform will provide detailed policy scenario analysis for Brazil at the national and regional level, including socio-economic impacts of the implementation of economic and environmental policies, and the environmental implications on food, water and energy use for the country.

Using one PDRA shared between UCAM and OU over 2 years, we will integrate to FTT:Agriculture variations in socio-economic factors such as agent discount rates and income, with land productivity defined on a GIS grid basis, and integrate the whole to E3ME, through a collaboration between UCAM, CE and OU. The model will be used to define a baseline scenario of land-use change for Brazil, identifying possible areas of conflicting demand for land between uses.

**Outputs:**

- E3ME-FTT global model of land-energy-water use, climate change and macroeconomics.
- Journal publication on a baseline scenario for land-use, energy use, water use and macroeconomics for Brazil in the global context.
- Journal publication on detailed model description and open-access code for FTT

**2.2 Improvement of the plant growth and land surface emulator**. Months 2-24. UCAM-OU

**Description:** FTT:Agriculture takes its land productivity information from a GIS-based suite of emulators, which have a robust representation of the impacts of any chosen scenario of climate change on land productivity and water availability (Bondeau et al., 2007; Oyebamiji et al., 2014; Holden et al., 2013; Holden, et al 2014) These emulators are already tested and working (e.g. Mercure et al., 2014), but more plant functional types are needed. With the same PDRA, the plant growth emulator (LPJmL) will be expanded to include more plant types with a larger dataset.

**Outputs:** An improved version of the plant growth and land surface emulator (LPJmL)
- Journal publication describing the model in detail with open access model code and database.

**WP3. Engagement with stakeholders and policy-makers**
WP Leader: Jorge E. Vinuales, UCAM. Schedule: Months 1-36

**WP3 Objectives**:
- Mapping of best-practice in policy intervention addressing the FWE-nexus.
- Engagement with Brazilian stakeholders and policy-makers for the analysis of the impact of global economic and environmental change in Brazil.

- Identification of sustainability objectives and initiatives taken by Brazilian stakeholders (particularly by representative portions of the private sector and civil society) and policy-makers addressing the FWE-nexus.
- Modelling, analysis and forecasting of the performance of different FWE-nexus policy interventions potentially adopted by Brazil to improve its the resilience to the challenges associated to the FWE-nexus.
- Mapping of current policy windows of opportunity and strategic proposals.

**Roles of Partners in WP3:** UCAM (JV) will lead, develop the research methodology and evaluate results in close collaboration with CE, OU, UNISUL. UNISUL will coordinate engagement with stakeholders and policy-makers collaboratively with law and governance experts from UCAM.

**3.1 Engagement with relevant policy-makers to map and analyse the current Brazilian political and policy context regarding the FEW-nexus.** Months 1-12. UCAM-UNISUL.

**Description:** This task will involve two specific pieces of work. The first is a systematic mapping to be conducted by the PDRA allocated to WS3 of best policy practices in addressing the FEW-nexus. The second will focus on creating links and engaging with Brazilian stake-holders and policy-makers to understand how the impact of economic and environmental change on the FEW-nexus is being felt (as well as perceived) in Brazil and whether specific responses have been adopted or are being considered. In order to determine the political and policy context within which policy action could be recommended as a result of this project and, more specifically, to perform the scenario-based iterative analysis envisioned in task 3.2, task 3.1. will involve close contact with Brazilian partners, stakeholders and policy-makers. Such contact will be achieved through travel by the UK partners, roundtables, stakeholder discussions and meetings.

**Outputs:** Report on best practices (months 1-6); Report on current political and policy context in regarding the FEW-nexus in Brazil addressing objectives 1, 2 and 3 of WP3 (months 1-12).

**3.2 Scenario-based iterative analysis for Brazil with stakeholders and policy-makers**. Months 18-36. UCAM-UNISUL

**Description:** WP3 entails a model-based analysis and forecast of future scenarios of global economic and environmental change and their impact on Brazil, carried out in collaboration with stakeholders and policy-makers. Scenarios will be modelled using the platform E3ME-FTT (WP2). They will represent the trajectories and impact on Brazil of: (i) economic changes within and outside of Brazil (influencing the Brazilian economy through international trade, investment and capital flows), (ii) global environmental change stemming from global emissions scenarios through carbon cycle and climate modelling (OU), and (iii) different policy actions taken by Brazil to respond to such trends.

Integrating items (i), (ii) and (iii) is critical because the outcomes of these scenarios will heavily depend on actions taken by both Brazil and the rest of the world; it is thus imperative that consideration of these possibilities is sufficiently comprehensive (e.g. whether global emissions reductions policies are adopted and implemented or not). Legally and politically workable policy instruments found relevant by experts in this project and through consultation with stakeholders and Brazilian policy-makers will be tested (introduced as item (iii)) in the modelling suite E3ME-FTT. These can include energy (demand and supply) sector policies (market, regulatory or technology policies), land use policies (market and regulatory) as well as economic policies (e.g. redistribution, environmental tax reform). Workable policy scenarios that reach chosen sustainability objectives will be identified in a two-way interaction with stakeholders and policy-makers. Findings of WP3 will be shared with stakeholders and policy-makers in an iterative process to identify acceptable policy scenarios that reach the chosen objectives. Such dissemination will entail a close collaboration with WP5.

WP3 will be led by experts in environmental policy and law at UCAM in close collaboration with partners at UNISUL, with 1.5 PDRAs in the UK, specialising in modelling, environmental policy and law, and shared staff from Brazil visiting periodically the UK. UNISUL will provide key information on the local context and contact with relevant stakeholders and policy-makers, in order to ensure impact of our research on policy-making in Brazil. Capacity-building will be carried out: the

analysis capacity from the UK will be transferred to the Brazilian partners through training, skills and information transfer, in order to build the ability to analyse sustainability policy problems.

**Outputs:** Report on politically and legally workable policy solutions to govern the FWE-nexus, taking into account future economic and environmental change, objectives 4 and 5 of WP3.

**WP4. Pilot Action –"Resilient Community"**
WP Leader: UNISUL. Schedule: Months 12-36.

**WP4 Objectives**: The objective of WP4 is to support the development and implementation of sustainable pilot projects to mitigate the impacts of the FWE nexus. In order to maximise the outreach and dissemination of the information, a multi-stakeholder approach has been taken, engaging public and private institutions. Among the stakeholders supporting the projects are AMUREL (municipalities association from Laguna region), Florianópolis City Council, Santa Catarina's State Secretary for Agriculture and Fisheries, EPAGRI (agricultural research and rural extension company of Santa Catarina), Tractebel Energia GDF Suez (energy company), Environment and Tourism Commission of the Santa Catarina State Legislative Assembly (Parliament of Santa Catarina State), Tubarão Environmental Foundation, Braço do Norte Environmental Foundation and Ideal Institute (non-profit organisation in Florianopolis that promotes renewable energies in Latin America). In this context, the WP4 is expected to:

- Engage with several institutions in the implementation of pilot infrastructure projects, fostering the regional dialogue between the stakeholders and target groups in the community.
- Raise awareness among regional stakeholders (local authority, policy-makers, energy providers, local companies, NGOs, citizens) about the challenges of the FWE nexus, and to promote sustainable practices
- Build capacity of key actors (local authorities, policy-makers, energy providers, local companies)

**Roles of Partners in WP4:** Brazil (UNISUL) will lead WP4. UCAM will provide expert input to the feasibility studies, making available know-how to the advantage of the UK-Brazil partnership.

**4.1 Pilot infrastructure projects**. Months 12-36. UNISUL-UCAM

**Description:** The pilot-action module "Resilient Community" will bridge the gap between theoretical approaches and practical use. Four main pilot projects will be implemented:

- **Sustainable Forest**: With the support of the UNISUL university experimental farm, sustainable land use management and farming practices will be promoted among key regional stakeholders. The main goal of this pilot is to promote deforestation and water protection measures to preserve the Atlantic Forest region of Brazil, an ecosystem of 1.3 million square kilometres vastly affected by deforestation and degradation.
- **Energy Forest**: Three demonstration projects will be implemented at the UNISUL university experimental farm to promote the sustainable production of energy from bio-waste. The first pilot will include the installation of a small bio-digester, to generate natural gas from animal waste. The second pilot will show how to produce biomass from agricultural and forestry waste. Finally, the third pilot will show how to produce biofuel (such as biodiesel and ethanol) from agricultural and forestry waste.
- **Less Hydro**: Given the imperative necessity of the country to diversify Brazil's energy matrix, the 'Less Hydro' pilot of BRIDGE will promote the use of solar and wind energy in Brazil through the installation of small electricity generation pilots based on solar PV and wind turbines at UNISUL campus. These pilots will help to promote the use of renewable generation technologies others than hydroelectricity, and to show the importance of having an energy sector resilient to water scarcity.
- **Green campus**: making UNISUL a site of sustainability best practice on campus, adopting energy and water efficiency strategies, recycling, green roofs (renewable energy) and cycling.

With the help of these pilots, feasibility studies will be carried out in selected communities, to analyse the possibility to replicate and/or scale up these projects. They will be developed in close cooperation with relevant local stakeholders to ensure that the needs and concerns of all key actors are appropriately taken into account. The specific actions to be implemented include:

- Identification of pilot community and potential infrastructure projects.
- Conduction of feasibility studies for those infrastructure projects.

- Preparation of report, presentations and dissemination of results to local stakeholders.

**Outputs:** Feasibility study reports and presentations to stakeholders for dissemination

**4.2 Regional Dialogue**. Months 12-36. UNISUL-UCAM

**Description:** Adopting environmentally sustainable measures is not feasible without political will as well as suitable political, financial and structural frameworks. Therefore, the BRIDGE project will use a multi-stakeholder approach, in which the key stakeholders from relevant sectors will be involved: industry, NGOs, entrepreneurs, farmers and citizens that play a role or are affected. In that context, the specific activities to be organised in the "Regional Dialogue" module include:

- Organisation of roundtables with the stakeholders and target groups in the pilot community
- Information events for regional stakeholders (local authority, policy-makers, energy providers, local companies, NGOs, farmers, citizens)

**Outputs:** Roundtables in the pilot community, Information events in the Pilot community

**4.3 Capacity Building**. Months 12-36. UNISUL-UCAM

**Description:** To ensure that concepts are successfully implemented, it is important that the regional key actors have adequate knowledge and skills about the relevant technical, management and financial aspects of the projects. Therefore, tailor-made capacity building interventions will be carried out for staff from local authorities, policy-makers, energy providers and local companies.

**Outputs:** Courses specially designed for staff from local authorities, policy-makers, energy providers and local companies. It will include training material, books and videos.

**WP5. Awareness raising & dissemination activities**

WP Leader: UNISUL. Schedule: Months 1-36

**WP5 Objectives**:

- Raise the awareness of local authorities; policy/decision-makers; energy/water/food providers; companies/entrepreneurs/farmers; general public in partner countries on the relevance of the potential socio-economic impacts of the food-water-energy nexus in Brazil;
- Promote resilience strategies to global change that contribute to the economic development and welfare of Brazil, particularly in terms of poverty alleviation and access to FWE services;
- To disseminate the BRIDGE project ideas and results.

**Roles of Partners in WP5:** UNISUL will lead and manage the transnational promotional, dissemination and networking events. The other partners will also provide inputs for the transnational promotional material and will develop additional regional material and host local or regional awareness raising events. An international conference will be held in the last year of the project, and it will be organised and hosted by UNISUL, Brazil.

**5.1 Communicational platform** Months 6-36. UNISUL-UCAM

**Description:** UNISUL, with the help of UCAM, CE and OU, will create a communicational platform that will centralise the academic material to be disseminated across the stakeholders, policy makers and academic community.

**Outputs:** Electronic and printed material, including website, brochures, posters and newsletters.

**5.2 Awareness raising events**. Months 6-36. UNISUL-UCAM

**Description:** UNISUL, with the help of UCAM, CE and OU, will organise local, regional and international events (including an international conference), to disseminate the projects ideas and results. These events will include local and regional awareness raising events, an international conference, and meetings with stakeholders as part of an iterative feedback process of bidirectional communication. Stakeholders include local authorities, policy-makers, decision-makers, energy/water/food providers, companies, entrepreneurs and general public. The researchers involved in the project will also attend external events such as conferences, fairs and workshops for networking and disseminating the project ideas and results.

**Outputs:** At least 4 local or regional awareness raising events, organised by UNISUL and UCAM, and an international conference.