UNIVERSITY OF PLYMOUTH

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EVIDENCE BRIEFING: COMMUNITY RESILIENCE AS KEY TO TACKLING LAND DEGRADATION

Summary

In times of economic, climatic and socio-demographic change, work to assess community resilience is gaining importance. This brief discusses insights from a study exploring a community's resilience, and its ability to respond, to land degradation. The approach here demonstrates the importance of considering the wider context to ensure policy interventions build momentum and secure engagement from local communities and stakeholders in solving pressing issues. Assessing a community's resilience helps explain why some policy initiatives are successful whilst others are not. Policy initiatives tackling environmental issues even have the potential to increase community resilience, improving understanding of how complex problems like climate change can be tackled. The approach outlined here seeks to overcome the interdisciplinary gap between specialist researcher groups, policymakers, practitioners and communities which lies at the heart of a collective failure to achieve greater socio-ecological resilience in the face of environmental challenges. The approach is scalable and applicable in other countries and cultures; it would also benefit the UK's Environmental Land Management (ELM) scheme.

A loss of community resilience often accompanies a decline in the community's natural resources. Losing natural capital is frequently associated with diminishing economic opportunities, outmigration and overall loss of services and livelihood quality at community level. The key is to find a balance between human needs and human pressures on resource use. Maintaining this balance, it is possible to reduce a community's impact on the environment whilst strengthening its resilience'
Dr Claire Kelly

Key points

- Efforts to address environmental issues such as soil loss and land degradation will be hampered if communities are not able to effectively respond and adapt to changes in their environment;
- If a community has the right set of skills, knowledge and tools it can thrive. Factors affecting community resilience are non-linear, interlinked in complex ways, and cumulative. Exploring how communities respond to challenges such as land degradation through a resilience lens offers an insight into how they could respond to other environmental challenges;
- Land degradation is a global issue driven by complex interactions between environmental, institutional, socio-economic, and cultural processes. It negatively impacts more than three billion people. Degraded land adversely affects soil health, biodiversity and the ecosystem services that are vital to life on earth;
- There is an urgent need for evidence-led sustainable land management interventions globally to reverse this degradation. To date, the formulation of policy solutions for achieving sustainable land management has been detached from those responsible for implementing them on the ground;
- This project sought to bridge the implementation gap between policy makers and practitioners and demonstrates that using portable soil scanner technology has the potential to fill key knowledge gaps, thereby improving resilience through community decision-making to the threat of land degradation;
- This project trial has demonstrated how portable scanner instrumentation can help farmers obtain soil quality information at plot scale quickly. This soil information could be particularly valuable in Tanzanian smallholder farming systems, where there is often a lack of targeted agricultural advice, and high variability in soil characteristics and other environmental factors. It could also help British farmers collect soil data as required under the ELM scheme;
- The combined nutrient and Soil organic carbon (SOC) data obtained by the scanner can provide an important basis to guide local land use decisions, particularly with regard to crop type and integrated soil fertility management strategies;
- This community-led testing process shows how portable technology can bring wider benefits in enhancing awareness of the importance of soil health for improved yields. It could strengthen resilience to future challenges by supporting the emergence of a new culture of innovation from within communities.

Context

Building communities' resilience to better prepare for, manage and respond to environmental issues such as soil loss and land degradation (and potentially climate change as well) has become an urgent necessity. There has, surprisingly, been little research to date exploring the interface between community resilience and key environmental issues, despite both being interconnected.

Building and strengthening resilience requires action from across the economy, from policymakers to businesses, to local government and communities. Environmental issues like soil erosion are a civic as well as a practical problem and every individual in the community has a stake in finding sustainable solutions.

Community resilience is the existence, development, and engagement of community resources by community members to thrive in an environment characterized by change, uncertainty, unpredictability, and surprise. Members of resilient communities intentionally develop personal and collective capacity to respond to and influence change, to sustain and renew the community, steering it towards a more prosperous future. Resilience is an ability to return to a state of stability or equilibrium following a disturbance event, or the ability to transform completely, and take a new path, when 'bounce-back' is no longer possible, to adjust to misfortune or change.

A resilience lens is useful in exploring how communities have experienced change, and how and why they have responded in a particular way. The speed and degree of change facing communities can be critical. Communities with lower levels of resilience may be able to adapt and continue where change is measured, and/or the speed of the adaptive response needed is gradual, or small. With the right set of skills, knowledge and tools, a community can make informed choices about how to manage its resources, enabling it to face future challenges with confidence.

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Exploring community resilience to land degradation

Using a resilience lens to explore how communities respond to challenges offers a way to investigate their resilience ahead of a policy intervention (or as a result of a policy intervention). Understanding the factors in the complex interplay between economic, institutional, social, cultural and natural domains, as well as the impact when one or more of these domains is disrupted, demonstrates how changes in one domain can create a ripple effect elsewhere. The following approach explores community resilience to soil erosion and land degradation.

Resilience and vulnerability can be understood as a spectrum; a resilient system always has 'positive' attributes while a vulnerable system tends to be dominated by 'negative' attributes. Factors affecting community resilience are non-linear, interlinked in complex ways, and cumulative. The assumption, based on a resilience–vulnerability spectrum, is that community resilience will be strongest at the intersection of the different domains (provided they are well developed). Weakening factors within one domain (i.e. increasing poverty) can also negatively influence factors in other domains (i.e. a reduction of social capital). Well-developed economic, institutional, social, cultural and natural domains are therefore crucial for resilient communities. Where change is rapid and significant however, a lack of balance between resilience domains, or an overdependence on one domain, may undermine the community's ability to transform, leading to fundamental change either in part, or all, of the community.

Factors	Description
Economic	(In)ability of communities to address economic aspects of land degradation processes e.g. lack of financial resources and/or opportunities to pursue alternative ways to earn a living. Increasing demand for, and over-use of, soils causing a vicious circle exacerbating existing erosion problems.
Social	Mediating the relationship between socio-economic and environmental factors. Interaction between community members through relationships, conflict resolution processes, engagement, learning and communication pathways as well as cooperation, networking and community 'cohesiveness'. Well-developed social factors signal the existence of adaptive capacity to deal with land degradation issues. In communities with weak social capital powerful stakeholders can override collective concerns and fragment community interests. They also change social dynamics, interrupting inter-generational communication, and disrupting social memory. When knowledge and experience gained over generations is lost, potential solutions to environmental problems are lost too.
Institutional	External processes that shape community-level decision-making i.e. 'outside' forces linked to institutional (and political) developments, can constrain autonomous decision-making processes and impact a community's ability to deal with land degradation. The devolution of responsibility for policy, the development of strong networks and partnerships between a range of stakeholders, as well as the presence of locally trained professionals, can facilitate the development of trust and knowledge transfer between local and regional stakeholders. Political factors are usually linked to existing ideologies and worldviews held by local, regional and national decision-makers. These can include worldviews of whether land degradation and soil erosion are seen as problems that warrant attention, investment and the implementation of effective policies to tackle them. Non-political institutions (e.g. universities) can also play an important role.
Cultural	Societal norms, conventions, traditions, rites and ideologies affecting decision-making processes in communities as well as the quality of economic, social and natural domains at community level. Ideologies shaped through religious, moral and other values directly affect local resilience pathways. Most communities will steer a pathway of compromise rather than leave behind the ideological and social influences from wider society.
Natural	Critical for understanding the vulnerability of soils, the risks associated with excessive water use and the repercussions of vegetation removal for land degradation processes. Can also include soil type and quality, water availability and quality, the steepness and accessibility of terrain, climate and type of vegetation.

Soil erosion and land degradation

Driven by complex interactions between environmental, institutional, socio-economic, and cultural processes, soil erosion and land degradation are issues in all parts of the world. They have a negative impact on more than three billion people, costing the world an estimated loss of more than 10% of the Global Domestic Product per annum[1] . Degraded land adversely affects soil health, biodiversity and the ecosystem services that are vital to life on earth. Today levels of land degradation, alongside wider socioeconomic and environmental challenges, threaten the productivity of many regional agricultural systems both in the UK and worldwide; healthy soils are the foundation of sustainable food production, underpinning regional food and water security.

1 IPBES 2018 The IPBES assessment report on land degradation and restoration ed L Montanarella, R Scholes and A E Brainich (Bonn: IPBES)

Issue

Critics argue that global capitalism has led not only to a substantial intensification of land use, but also to a loss of flexibility for community-level autonomous decision-making, thereby increasing erosion and land degradation. There is an urgent need for evidence-led sustainable land management interventions to reverse this degradation of natural resources. To date, the formulation of policy solutions for achieving sustainable land management has often been detached from those responsible for implementing such solutions on the ground. In addition, whilst institutional, policy and governance mechanisms can address land degradation issues, these mechanisms are often missing accurate and locally accessible soil health data. Collecting such information for each individual community is usually beyond the community's means and contributes to the failure to address the ultimate causes of land degradation.

Recent analysis has predicted that the greatest increase in soil erosion rates into the 21st century will occur in Sub- Saharan Africa, South America and Southeast Asia. Here, climate change, population growth, political upheaval, land tenure change, and migration have put unprecedented pressure on natural resources. A recent United Nations Convention to Combat Desertification (UNCCD), and FAO Land Degradation Neutrality ambitions, have called for action to halt current levels of soil degradation by promoting sustainable soil and land management practices to lift communities out of poverty and ensure population health. Halting soil degradation poses many challenges for resource-poor East African farming communities. Primary production systems are under stress, nutritional choices are changing and the relationship between development and agriculture is undergoing profound transformation.

Addressing the issue

This project in the Lake Manyara catchment system in Tanzania sought to bridge the implementation gap between policy makers and practitioners with a participatory approach, engaging stakeholders in the co-design of potential solutions to local soil erosion issues. The location represents a natural 'socio-ecological laboratory', typical of East African Rift System catchments, supporting vulnerable pastoral and agricultural communities.

It is important to bridge the implementation gap between policy makers and practitioners with a participatory approach, engaging stakeholders in the co-design of potential solutions

Previous research here found that pastoralists and farmers had a high level of awareness of soil erosion issues and their impact. Perceptions of the root causes differed but most participants identified the implications of erosion for their livelihoods, reducing the availability of pasture and poorer soil quality, as well as concerns about the future and opportunities for the next generation to make a living. Most shared a perception that urgent action needs to be taken to address the problem but identified some barriers to change including the availability of economic resources, and individual perceptions of risk, as well as issues related to local governance, community cohesion and cooperation.

Several avenues to change emerged from this early work, including the importance of formal education about sustainable practice, inter-community exchange, and NGO-driven, as well as government-led, education and support. It was clear that participants were open to gaining new knowledge to deal with the challenges; many demonstrated an openness for learning, education and participatory decision-making in the community to tackle land degradation. Several participants highlighted the need to develop the communities' capacity for innovation and to draw on internally-held resources to become less dependent on external support in the future.

The project aimed to realise the potential for a shift in power towards the farmer-citizen; generating research from inside the farm rather than from outside

There is an urgent need for accessible technology to assess soil health parameters in Northern Tanzania to enable communities to design long-term soil erosion repair and rehabilitation plans, alongside sustainably increasing crop yields to maintain livelihoods. A follow-up project aimed to develop and trial citizen science protocols to enable community diagnosis of soil health using nutrient status, SOC content, cation exchange capacity (CEC), and soil textural class within erosion risk frameworks from prior research. Using a 'collaborative citizen science' approach, farmers, along with NGO partners, had critical input into the project design and delivery. The project aimed to realise the potential for a shift in power towards the farmer-citizen; generating research from inside the farm rather than from outside. The project's approach was for farmer-citizens to begin to define their own farm-specific research needs whilst having the space to explore opportunities for experimentation and innovation.

The project was structured around three specific objectives; (a) to introduce a farmer-led opportunity to test portable agricultural technology in one specific community context; (b) to provide smallholder farmers with practical 'hands-on' sessions to test the kit; and (c) elicit views on the wider applicability of this type of agricultural technology in low-resource settings. Farmers chose the scanning locations on the farms themselves and, once all the scans were completed, the raw data was downloaded from the online portal and then integrated within existing land cover and erosion risk maps (obtained from a drone survey during previous research). The resulting maps provided a spatial representation of soil health in the village allowing for an easy comparison of soil health within fields and farmsteads.

The development of portable instrumentation, such as the AgroCares portable soil scanner, enables high spatial resolution data to be obtained from measuring SOC in African soils with portable near infrared spectroscopy (NIR). These devices have the potential to be a tool for mapping farm-to-community soil health characteristics and are capable of providing rapid, in situ data to inform soil management decisions and empower stakeholders to create a sustainable community landscape plan.

With the right set of skills, knowledge and tools, a community can make informed choices about how to manage its resources

Soil organic carbon (SOC)

SOC is widely accepted as a key indicator of soil health as it underpins a range of functions such as maintaining healthy soil structure and moisture, enhancing CEC, pH buffering, and the provision of nutrient pools and microbial diversity. Access to up to date and accurate SOC data as a proxy for soil health would support the mission to reduce and reverse soil degradation, but such data is not readily available to the majority of smallholder farmers and pastoralists in these contexts. With access to the data to address underlying causes of land degradation, local and global communities, as well as policymakers and practitioners, have the information needed to develop appropriate responses. Farmers often lack in depth scientific knowledge to evaluate soil health and rely on visual such as soil texture and colour. The ability of portable soil scanners to quickly deliver in-situ data on multiple soil health indicators allows farmers to measure, report and verify sustainable land management outcomes for wider community and regional benefit.

The project delivers into the UN Food and Agricultural Organisation (FAO) World Soils Charter 'to manage land for long-term advantage rather than for short-term expediency'

Results

Most farmers used the scanner to test differences in areas where they had previously identified good and bad productivity. The high variability in the results at the farm, and sometimes the plot level, demonstrated that the soil scanner could potentially provide meaningful information on soil quality. A total of 42 soil scans were performed on 23 different farmsteads and on communal village land. The output from the soil scanner highlighted spatial differences in the soil parameters across the area. The most distinct finding was that degraded rangelands had significantly lower Phosphorus, Nitrogen and Carbon contents (TP, TN, TOC) and significantly higher CEC. The relatively lower nutrient content in rangelands may be the result of fertilizer inputs on croplands, different soil types, the higher rates of soil erosion in the downstream rangelands due to flow accumulation, or a combination of these factors. The scanner did not however pick up a difference in soil texture between rangelands and cultivated soils so the significantly larger CEC values of the degraded rangelands might also be related to specific differences in clay mineralogy or soil type.

This trial has demonstrated how portable scanner instrumentation can help farmers quickly obtain soil quality information at plot scale. This soil information obtained could be particularly valuable in Tanzanian smallholder farming systems, where there is often a lack of targeted agricultural advice, and high variability in soil characteristics and other environmental factors. One particular benefit of scanner use in this study is the measurement of SOC. This valuable resource has shown decline under intensive agricultural systems in Sub-Saharan Africa and the loss of SOC can lead to physical, chemical and biological degradation. Building and maintaining healthy SOC pools is acknowledged in the UNCCD as essential for underpinning soil ecosystem services and achieving global Sustainable Development Goals (SDGs). This study shows that targeted measurements of SOC can be used to inform local-scale land use planning and complement wider measurements of soil health such as aggregate stability and infiltration capacity.

Discussions with the 'citizen science' farmers showed that combined nutrient and SOC data obtained by the scanner can provide an important basis to guide local land use decisions, particularly with regard to crop type and integrated soil fertility management strategies. Maintaining and building SOC also requires the addition of quality organic matter (OM) to the land. This is particularly challenging in Sub Saharan Africa where biomass is often used for livestock fodder at the expense of return to the soil. The type of OM applied to the soil greatly influences SOC fractions. It also plays an important role in nutrient cycling. Application of crop residues with low nitrogen and higher lignin and phenol content is less likely to build active SOC pools and improve yields when applied in isolation. To improve yields instead the addition of quality OM (i.e. from legume cover crops) is necessary; these decompose more readily thereby contributing to more rapid nutrient cycling.

At the international level, the project delivers into the UN Food and Agricultural Organisation (FAO) World Soils Charter 'to manage land for long-term advantage rather than for short-term expediency' (FAO 2015). It shows that agritech can also provide a shared learning opportunity, raising awareness of the importance of maintaining and enhancing SOC and helping to foster intrinsic motivation to implement sustainable solutions. Using the scanner can not only identify areas where SOC is generally depleted, but the combined nutrient and SOC information can support those who give advice in tailoring it to develop strategies which foster the application of a range of SOM types for the benefit of soil health and associated yields.

Scanning to support community resilience

Study participants discussed how they had used data from scans of their land during the testing programme to improve soil health and adapt farming practices. Some noted that they had already improved their crop selection and soil management techniques by combining the knowledge generated by scanning soil on their land with technical advice provided by local agricultural advisory services. However, the workshop participants noted that in most communities in the region, there is currently little farm- or community-specific tailored technical advice available to determine crop choice based on soil type, profile, or nutrient status (other than general advice on the use of inorganic fertilisers and contour ploughing). Most participants felt that they had had good knowledge of local markets and the potential economic viability of crops, but little knowledge about maintaining soil health through sustainable land use methods, or how to plan longer term approaches to improving soil health.

Participants highlighted how the technology could be integrated with existing expertise available through the District Council and local agricultural and producer networks. Whilst the majority of farmers in the community do not have access to smartphones, some community members do and it was recommended that selected representatives, such as the Village Committee and local Agricultural Extension Officers, could be trained in how to use, read and interpret data from the soil scanner. This would be an opportunity for expanding wider training and links with local schools and education programmes, creating a network of soil health expertise at the village level. As a first step, a short course was organised in the local university, where a number of scientists were trained in the use and interpretation of the soil scanner to enable them to continue to use the scanner and train other practitioners.

In the project communities there is significant interest in using this technology to support better micro-scale management of plots, and willingness to use the data produced alongside additional guidance from Extension Services, to adopt sustainable land management practices. Learning by demonstrating is likely to be a particularly important and effective tool to encourage farmers to adopt locally tailored Sustainable Land Management (SLM) techniques. Community members were keen to understand more about the technology; those who had not participated in the testing programme showed significant interest in learning more about the scanner, and how to improve soil health on their own land.

This community-led testing process has provided a key mechanism to show how portable technology can bring wider benefits in enhancing awareness of the importance of soil health for improved yields. Participants highlighted the need for more scanning in other community areas, including private and communal land, to provide a comprehensive profile of local soil type and health status. This data should then inform updates to the community's Land Management Plan and address existing severe soil erosion and land degradation challenges. Discussions also focussed on governance (equity of access) and economic sustainability of the technology and its potential as an income-generating stream for farmer co-operatives in general.

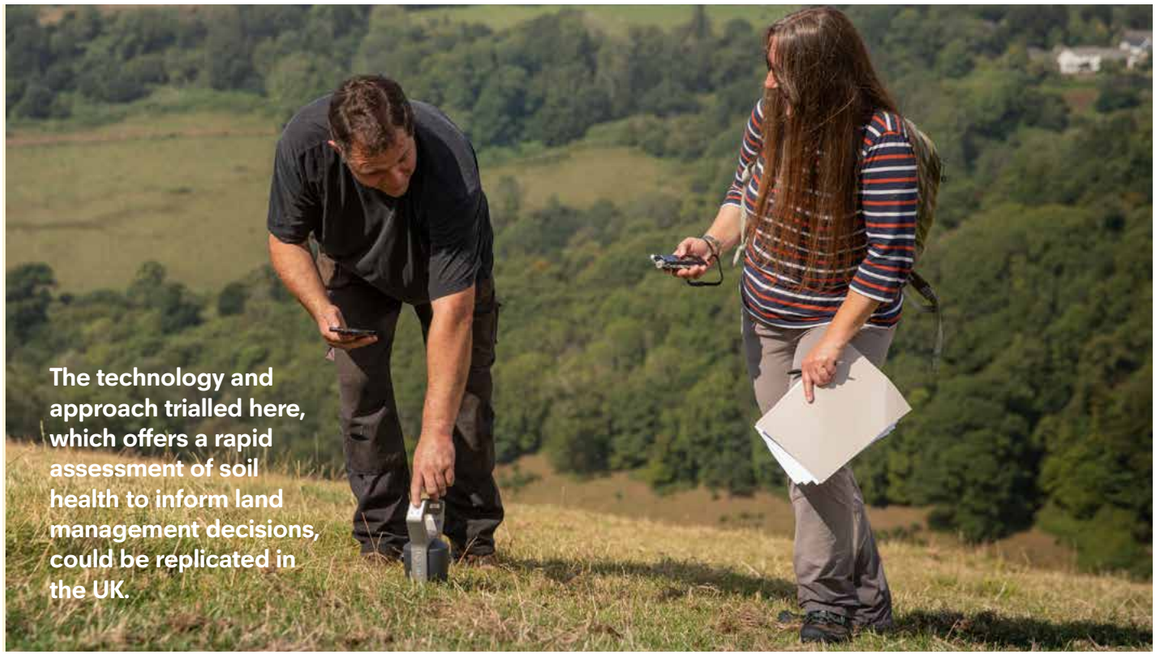
Participants discussed how they had used data from scans of their land during the testing programme to improve soil health and adapt farming practices.

Conclusion

There is an urgent need for diverse evidence-led sustainable land management interventions to reverse the degradation of natural resources globally. Pastoralist communities worldwide face complex challenges regarding food and feed productivity, compounded by climate variation and multi-scalar socio-economic processes. This project demonstrates how using portable soil scanner technology to develop a targeted soil organic matter and nutrient status dataset, in a small catchment-based community setting, will help strengthen the community's resilience to future challenges. This technology offers a rapid assessment of soil health to inform land management decisions and represents a step change from existing piecemeal data gathering by external actors. As well as a range of positive benefits, there are practical challenges when using the technology in this context. Governance processes locally need to be understandable so that actors from multiple spatial levels can connect and engage with each other more effectively. Analysing and interpreting the resulting data will require external expertise. Care needs to be taken to ensure that all resulting advice is appropriately tailored to local climatic conditions and is relevant in terms of the availability and accessibility of markets for specified crops.

Future citizen science studies should aim to increase the sample resolution and also perform an independent quality assessment to focus on the ability of the scanner to pick up relative differences in the soil quality parameters. These findings could build resilience to future challenges by supporting the emergence of a new culture of innovation from within communities. The information and experiences gained here can be used to inform and contribute to the adoption of co-management approaches elsewhere, supporting the integration of externally-derived knowledge with a context-relevant community/stakeholder-driven approach. The UK's three-tier Environmental Land Management (ELM) scheme aims to put soil health at the heart of future farming policy. One of the challenges of implementing this scheme is gathering reliable data on soil heath. The technology and approach trialled here, which offers a rapid assessment of soil health to inform land management decisions, could be replicated in the UK.

Holistic, interdisciplinary systems thinking is required to deliver outcomes that empower local communities to break out of the vicious circle of land degradation. When human-environment systems are viewed and treated holistically, the solutions proposed should enhance the likelihood of sustainable long-term change leading to a rebalancing between socio-economic and ecological resilience.



The technology and approach trialled here, which offers a rapid assessment of soil health to inform land management decisions, could be replicated in the UK.

Photograph: Carey Marks Photography

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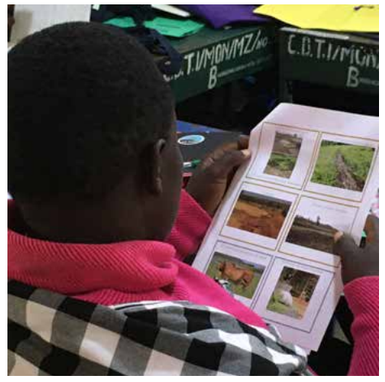

UNIVERSITY OF PLYMOUTH
Sustainable Earth Institute

Evidence summary for policymakers

Relating to the following Global Sustainable Development Goal

A three-time winner of the Queen's Anniversary Prize for Higher and Further Education, the University of Plymouth is renowned for high quality, internationally-leading education, research and innovation.

The **Sustainable Earth Institute (SEI)** connects the University's world leading research expertise with the wider world to collaborate on creating a more sustainable future. We bring together researchers from natural and social sciences, engineering, arts, humanities, health and business, to take an interdisciplinary, systems-thinking approach to help tackle sustainability challenges.

This Policy Brief is part of a series aiming to inform policy-makers of our sustainability research, in particular around Net-Zero Carbon and Healthy Landscapes.

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Voice of a sustainable earth

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Dr Claire Kelly is a Senior Research Fellow at the University of Plymouth's School of Geography, Earth and Environmental Science and a Senior Lecturer in Quality Management and Research in the Peninsula Medical School. A social scientist and a geographer, she leads and collaborates on interdisciplinary research projects focussing on people and their relationships to place across a range of contexts. She focuses on social capital, resilience, stakeholder engagement and partnership working, governance and participation and qualitative research method development. Dr Kelly has extensive experience of engagement at community level both in the UK and abroad; she also works with community arts organisations, such as Beaford Arts, to design and support the delivery of public engagement with science projects.

for Research in Environment and Society (CeRES) and her Doctorate (PhD) in Geography explored the effectiveness of public/private sector partnerships within the complex and fragmented policy environment of the coastal zone.

The University of Plymouth has a national and international track record in specific areas of data acquisition as well as the interpretation and visualisation of environmental data. It is currently working draw these strengths together to deliver the next generation of environmental monitoring and assessment. Building on research bases within environmental monitoring and fate, sensors, agri-tech, and biology we have formed a University-wide Sensors group, which is already forging new collaborations and gaining funding.