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DSH

DATA AND DECISION MAKING

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FOREWORD

The Baroness Willis of Summertown cbe

In the UK and around the world, the way we use data is transforming how we understand, plan for, and protect our environment. The rapid growth of digital tools and accessible, high quality datasets is helping policymakers, researchers, and communities map the future environmental landscape with unprecedented clarity. This shift could not be more timely.

As we confront complex challenges from climate change, from rising flood risks to biodiversity loss and extreme weather, we need decision making that is not only evidence based but grounded in trusted, integrated, and transparent data.

Nowhere is this more critical than in policy areas where social, economic, and environmental pressures intersect. Building more homes to address the UK's housing shortage, for example, must go hand in hand with efforts to reduce carbon footprints, improve climate resilience, and safeguard natural systems. Decisions of this scale increasingly rely on the ability to explore geographical patterns of vulnerability such as age, health, deprivation, or exposure to heat - alongside environmental risks like flooding or coastal change. These insights offer a more holistic understanding of the communities most affected and the interventions most likely to succeed.

The importance of using reliable, authoritative data sources cannot be overstated. Environmental data collected by trusted organisations ensures that policy choices reflect the best available evidence. Tools like The Digital Solutions Hub (DSH) play a vital role in enabling this. Created in collaboration with the Natural Environment Research Council, this online toolkit creates a single, open-access space where environmental data can be easily found, visualised, and used.

As Chair of a cross-party climate and nature action group in the House of Lords, and a member of the House of Lords Science and Technology Committee, I am acutely aware of the need to have access to reliable environmental, social, health, and economic data. This is particularly important as legislators look for creative ways to deliver environmental and climate goals while also supporting wider social and economic priorities.

The Digital Solutions Hub will open up new opportunities not only for deeper analysis, but also for collaboration across Whitehall, the devolved nations, local government, academia, and the wider research community. It will allow us to model and visualise complex spatial relationships and provide important new capabilities for policymakers and researchers alike.

Digital innovation is now pivotal in helping to unlock policy challenges, illuminate emerging risks, and empower better decisions. As we continue navigating a changing climate and increasingly complex policy landscape, the role of accessible, trusted data will only grow in significance. This publication sets out the importance of that journey and the digital tools that will help shape the decisions of tomorrow.

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Crossbench Peer and Chair of Peers for the Planet, House of Lords

THE ROLE OF DATA IN SUPPORTING DECISION MAKING: UTILISING SPATIAL DATA AND GIS FOR INFORMED POLICY AND PRACTICE

Professor Richard Kingston

In an era marked by rapid technological advancement and ever-increasing complexity, the ability to make informed, timely decisions has never been more vital. Across government, industry, academia and the public sector, organisations are striving to integrate digital solutions that enable evidence-based policy and practical action. Central to this endeavour is the use of data: not just as a passive resource, but as an active driver of insight, accountability and innovation.

The NERC Digital Solutions Hub (DSH) stands at the forefront of this data-led transformation. By leveraging the power of spatial data and Geographic Information Systems (GIS), the Hub provides a suite of tools and methodologies to support robust decision making, tackle environmental challenges and maximise the value of NERC's and other UK data assets.

Sound decision making requires not just access to data, but the means to interpret it, integrate it with other evidence and apply it to real-world contexts.

THE CENTRALITY OF DATA IN MODERN DECISION MAKING

The scope and scale of data available to contemporary decision makers has grown exponentially. Data now flows from a multitude of sources: satellites circling the Earth, sensors in urban infrastructure, user-generated content, and vast repositories of government and academic research. This wealth of information presents enormous opportunities, but only when harnessed effectively. Sound decision making requires not just access to data, but the means to interpret it, integrate it with other evidence and apply it to real-world contexts.

Here, the DSH's approach is instructive. By focusing on the collection, curation, and analysis of spatial data, it ensures that decisions are grounded in a detailed understanding of place, context, and change.

DRIVING INNOVATION

The DSH is a flagship initiative of the Natural Environment Research Council, designed to transform the UK's ability to generate, share, and apply environmental data. The programme's objectives are ambitious: to break down barriers to data access, foster cross-sector collaboration, and unleash the potential of digital technologies in addressing key environmental and social challenges.

Among its primary contributions is the promotion of spatial data infrastructures, which bring together diverse datasets and make them available through intuitive, interoperable platforms. This has profound implications for decision making; empowering policy-makers, planners, and researchers with the timely, high-quality evidence they need.

ENABLING EVIDENCE-BASED POLICY

One of the most significant impacts of the programme is its ability to underpin evidence-based policy. Through the integration of spatial data and GIS, decision makers gain access to a rich tapestry of information on land use, biodiversity, climate change, human health, population dynamics and more. This enables the identification of trends, risks, and opportunities that might otherwise remain hidden.

For example, spatial data can illuminate patterns of urban expansion, highlight areas of environmental vulnerability, or support the targeting of resources to communities most in need. The capacity to visualise and map these factors, often in real time, greatly enhances the effectiveness of policy interventions.

SUPPORTING CROSS-SECTOR COLLABORATION

The challenges facing society, from climate change to housing provision, cannot be solved by any one sector alone. The DSH recognises this, fostering collaboration and knowledge exchange across government, academia, industry, and civil society. By providing shared access to spatial data and digital tools, it helps break down traditional silos and enables collective action.

Notably, the programme has supported a range of demonstration projects where data-driven decision making has delivered tangible benefits. These include urban flood mapping, climate change impacts on housing and communities, air pollution impacts on human health, habitat restoration planning, and infrastructure development, each underpinned by robust spatial analysis and stakeholder engagement.

THE POWER OF SPATIAL DATA, GIS AND MAPPING

Spatial data, information about the location, shape, and relationships between physical features, lies at the heart of efforts to understand and manage complex systems. When combined with the analytical and visual capabilities of GIS, it becomes a transformative asset for decision support.

Notably, the programme has supported a range of demonstration projects where data-driven decision making has delivered tangible benefits.

GIS enables users to layer multiple datasets, revealing how different factors interact across space and time. For instance, environmental managers can overlay maps of soil type, land cover and rainfall to assess flood risk, while public health officials can combine demographic and pollution data to identify at-risk populations. Such integrative analysis is crucial for holistic, system-wide decision making.

SCENARIO PLANNING AND FORECASTING

Beyond describing the present, spatial data and GIS are invaluable for exploring possible futures. Decision makers can build scenarios, testing how different policies, investments, or events might shape outcomes, and use these insights to plan for resilience and sustainability. The DSH provides the data infrastructure and insight needed to support such forward-looking approaches.

SPATIAL DATA IN ACTION

Consider the challenge of managing urban green spaces. Local authorities must balance competing

demands for recreation, biodiversity, urban cooling, and new housing, often with limited resources. Through the DSH, councils can access up-to-date spatial datasets on land cover, public accessibility, and ecological value.

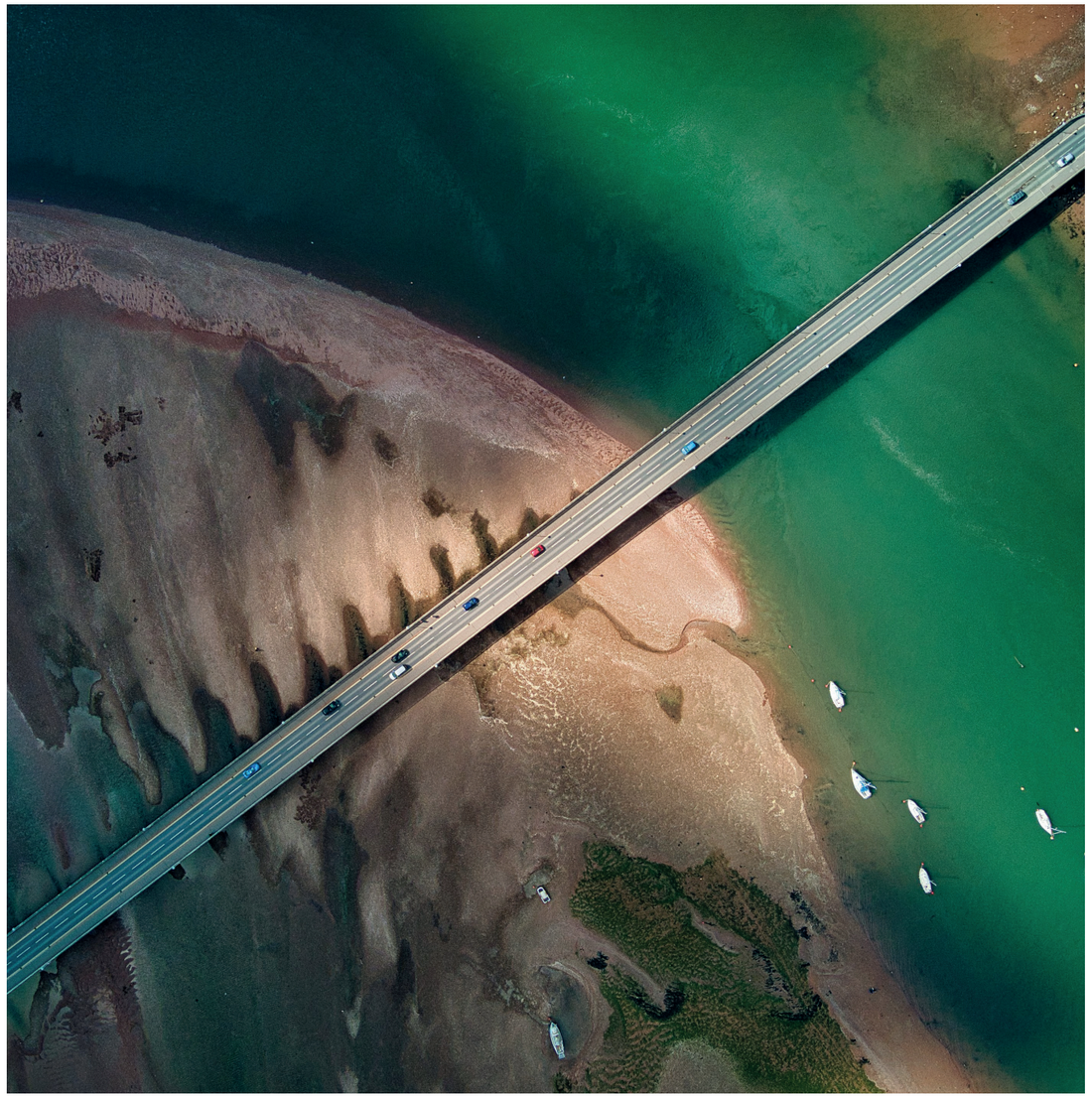
Using GIS, planners can map current provision, identify gaps, and model the impacts of proposed developments. This empowers them to make defensible, evidence-led decisions that reflect both community needs and long-term sustainability goals.

Poor or inconsistent metadata remains a major barrier to data discovery, reuse, and integration, even where datasets comply with established standards

CHALLENGES AND FUTURE DIRECTIONS

While the potential of data-driven decision making is immense, it is not without challenges. Data quality, interoperability, and metadata are critical to ensuring that data delivers public value. Poor or inconsistent metadata remains a major barrier to data discovery, reuse, and integration, even where datasets comply with established standards such as the UK Government Data Standards and the INSPIRE Regulations. The DSH is addressing this gap by building capability and promoting clearer, more consistent, and machine-readable metadata aligned with standards and applying the FAIR principles. Strengthening metadata quality, particularly around provenance, update frequency, uncertainty, and fitness for purpose would significantly enhance interoperability and support more effective, evidence-based decision-making across government.

Going forward, there is an urgent need to democratise access to spatial data and GIS tools so that communities, businesses, and policymakers can meaningfully participate in the data revolution. This requires coordinated action at national level, particularly from The Department for Science, Innovation and Technology for data standards, digital skills and infrastructure and The Department for Environment, Food and Rural Affairs for environmental data and public-sector geospatial assets, working with NERC and devolved and local government to reduce barriers to access and use.



Targeted investment is needed in applied spatial data training, including core data literacy, metadata and data stewardship skills, and practical GIS and analytics capabilities for non-specialists across the public and third sectors. International examples such as national geospatial knowledge hubs and open geospatial communities (e.g. cross-sector geospatial networks in the Netherlands and Finland) demonstrate the value of sustained collaboration between government, academia, industry and civil society through online communities, regular practitioner forums and joint innovation programmes. The DSH contributes to this agenda by providing open platforms, shared tools, and collaborative networks that support skills development, knowledge exchange, and co-production between data providers and users, helping to translate spatial data into more inclusive and effective decision-making.

CONCLUSION

The role of data in supporting decision making has never been more critical. Through initiatives like the DSH, the UK is laying the foundations for a more informed, agile, and resilient society. By harnessing the unique power of spatial data and GIS, we can better understand the world around us, anticipate future needs, and deliver policies and actions that are both effective and equitable.

As we look to the future, continued investment in data infrastructure, capacity building, and innovation will be essential. By doing so, we can ensure that data fulfils its promise as a driver of positive change across the environment, health, economy, and society.

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BEYOND THE QUERY: TRANSFORMING ENVIRONMENTAL DATA DISCOVERY WITH LLMS

Professor David Topping

Environmental problems are complex, evolving issues that defy straightforward solutions. These challenges demand integrated data, yet current environmental data is scattered and hard to access. Artificial intelligence (AI), alongside strong metadata frameworks, is emerging as a powerful tool for breaking down barriers to data discovery. The importance of access to quality data in solving environmental problems, the issues associated with this access and ways to unlock the potential for environmental data to inform real-world solutions in the UK is more easily enabled by the DSH.

ACCESS TO ENVIRONMENTAL DATA IS NOT *FAIR*

Data collection is integral to environmental science. Yet just as research efforts are siloed, so too are the digital infrastructures that house environmental data in the UK. Although a recent review suggested that environmental science compares favourably to other disciplines in terms of alignment with the FAIR data principles, our Digital Solutions Hub User Research Report with environmental data users across the UK revealed significant and persistent barriers to data access and use. Open data, while commendable, is not necessarily discoverable or automatically useful.

This presents a challenge for science and policy in the environmental domain. Many issues we face are known as 'wicked problems'. These are complex, evolving issues that are hard to define, involve diverse and often conflicting interests, and defy straightforward solutions. Environmental problems are emblematic of this, as they sit at the intersection of ecological, social, economic, and political systems.

Such interconnected challenges demand equally integrated data. The current state of environmental data, which is scattered, unevenly curated, and often difficult to access, makes it hard to draw links between phenomena such as climate projections and health outcomes. The INSPIRE Regulations 2009 set out to counter this and facilitate better public access to spatial information across Europe, yet there is still much to be done to achieve this integration.

THE ROLE OF AI AND METADATA IN BETTER DATA DISCOVERY

AI, especially Large Language Models (LLMs) offer a transformative opportunity in how we search and interact with data itself. Public attention has largely focused on the generative and conversational capabilities of LLMs, which have revolutionised search, discovery, and digital assistance. However, these same technologies can be harnessed for good to answer domain-specific questions that traditionally require expert triage and access to siloed data sources. Imagine visiting a platform and asking: "What data can help me understand the impacts of transport emissions on public health?" In the traditional model, a team of experts might unpack this into a series of scenarios, identify relevant datasets, and design an analytical pipeline. Assuming that they know where and how to access the right data.

A key technology enabling this shift is retrieval-augmented generation. This approach allows LLMs to augment their responses by pulling in relevant information from external sources, be it documents, datasets, or structured metadata. If metadata describing datasets are embedded using this approach, then even imperfect or incomplete descriptions can still be matched semantically with user queries. Suppose a user asks for data on health impacts from mould exposure; a complex combination of atmospheric and clinical science, atmospheric monitoring and social behaviour. Even if the metadata does not explicitly mention mould but references composting emissions, an LLM might still identify the dataset by associating composting-related spores with respiratory outcomes thanks to its semantic understanding. LLMs can also be used to improve metadata quality by supplementing, standardising or inferring missing fields. Of course, there are evolving barriers around public trust of results generated from such tools.

By integrating LLMs with strong metadata frameworks and participatory design, the DSH empowers policymakers to discover evidence more efficiently, trace its provenance, and apply it with confidence to address urgent environmental challenges.

The NERC Digital Solutions Programme, have worked directly with environmental data users to ensure that AI-powered tools available on the DSH are grounded in practical needs. By integrating LLMs with strong metadata frameworks and participatory design, the DSH empowers policymakers to discover evidence more efficiently, trace its provenance, and apply it with confidence to address urgent environmental challenges. In doing so, we are not just improving data access, we are reimagining what responsive, AI-enhanced environmental science can look like.

CENTRE ENVIRONMENTAL PROBLEM-HOLDERS IN POLICY DESIGN

Policymakers should be at the forefront of technological development. By engaging directly with initiatives like the DSH, they gain early visibility into practical use cases, opportunities, and challenges. This insight enables them to advocate for and shape policy that supports innovation while ensuring ethical, equitable, and sustainable deployment. This is timely as the UK government's AI Action Plan acknowledges that trustworthy, high-performing AI will be essential to achieving the government's missions, from building an NHS fit for the future to making Britain a clean energy superpower.

Regulations and investment strategies should reflect the realities of interdisciplinary, applied science and support actionable insights. To strengthen engagement with on-the-ground expertise this could include establishing a cross-sector expert panel focused on AI and environmental data, like that seen in GO-Science, with rotating membership from academia, public bodies, and practitioners, therefore embedding more agile, domain-specific expertise into government decision-making.

BUILD CAPACITY WITHIN PUBLIC SECTOR ORGANISATIONS

Whilst the UK's principles-based approach differs from other developing global governance models for generative AI, emerging collaboration agreements between the EU and UK will support joint development of new tools around, for example, AI factories. This might lead to appropriate governance by design. However, to effectively address the challenges of fragmented data landscapes and unlock the potential of AI technologies, all policy-driving organisations, including government departments and local authorities, should develop or update their AI strategies.

If public sector bodies move quickly to adopt and model good data practices, they can set visible standards that places constructive pressure on the wider technology ecosystem.

The AI playbook, released this year, provides government departments and public sector organisations with accessible technical guidance on the safe and effective use of AI. However, they need to go further so that government can ensure their public services can deliver the best possible outcomes for citizens and businesses across the UK. DSIT should ensure that AI strategies are grounded in a clear understanding of the current data ecosystem, the evolving landscape of generative AI tools, and infrastructure needed to enable responsible, scalable adoption. To achieve this, DSIT should invest in training and infrastructure, and facilitate access to expert guidance within government agencies to assist with their AI strategies. If public sector bodies move quickly to adopt and model good data practices, they can set visible standards that places constructive pressure on the wider technology ecosystem.

Now is the time to explore the use of LLMs for data search and discovery. A growing ecosystem of tools and platforms already exists, many of which can be trialled with minimal investment and without becoming dependent on proprietary solutions. These tools, such as the DSH, are not only accessible but are being taught and adopted by the next generation of scientists, analysts, and civil servants. Building awareness, testing these technologies in real-world contexts, and learning from early implementation efforts is a cost-effective, future-proof step that organisations can take now.

David Topping is a Professor of The Digital Environment at The University of Manchester.

THE DIGITAL SOLUTIONS HUB

THE BACKGROUND

The NERC Digital Solutions Hub (DSH) is an online open-access toolkit that allows users to easily discover, visualise, map and tell stories using environmental data from NERC's (Natural Environment Research Council) data centres. The Hub will also bring together a range of other environmental, social, health and economic data from trusted sources like the Department for Environment, Food and Rural Affairs, the Environment Agency, and the Office for National Statistics.

The DSH has been designed with all users in mind, meaning that should a user have no experience in GIS (geographic information systems) they will still easily be able to use and benefit from the Hub – complying with the FAIR data principles: findable, accessible, interoperable and reusable.

Users will be able to upload their own data sets to use alongside the environmental, social, economic and health data within the Hub.

FUNCTIONS

AI AND LARGE LANGUAGE MODELS

The DSH uses artificial intelligence (AI) and large language models (LLMs) to aid users to not only search for data but discover data sets too. The DSH allows users to search semantically through the use of an AI chat bot for the data they are looking for e.g. 'Where will the wettest place be in the UK in 2050?'. The Hub will then offer users a list of relevant data sets related to their search question, aided by the LLM, for them to visualise, map, analyse and tell stories with.

The AI and LLM in the DSH has been trained only on the trusted data sources within the Hub, which is mostly academic paper abstracts. Users can thus be reassured that they can trust the results offered by the AI chat bot, as all the information offered to the user originates from the data itself, not any external information.

THE UPRN SERVICE AND REAL TIME DATA

On top of the environmental data the DSH will host a variety of real-time data that will be available down to the local neighbourhood scale due to the integrated UPRN service.

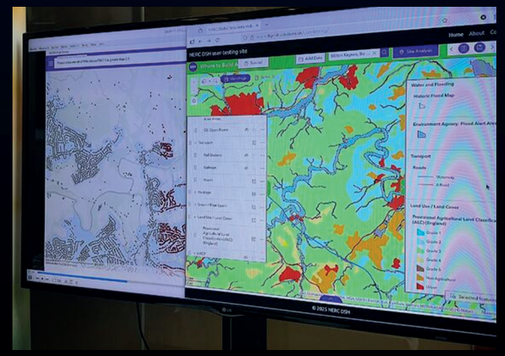
UPRNs, or Unique Property Reference Numbers, are individual identifiers for civil, domestic and commercial buildings that allow data to be pinpointed down to a neighbourhood scale. It is essentially an X-Y coordinate for the central location of a building. The combination of real-time data with UPRNs in the DSH will transform decision-making through the understanding of local environmental changes and pressures on communities.

CASE STUDIES

CLIMATE READY NATION

The Climate Ready Nation functionality allows users to see the art of the possible. It focuses on the applications of the DSH for sustainable housing expansion. It empowers local authorities, planners, and developers to better align housing expansion with environmental, social, and economic goals through access to a wealth of environmental data, and the ability to model and visualise complex spatial relationships.

Through improving access to a wide range of environmental, social, economic and health data sets the DSH allows local authorities, planners and housing developers to address key challenges such as; land suitability and environmental considerations, infrastructure and connectivity, and supporting decarbonisation and climate adaptation. Further, it allows local authorities to contribute to the Government's Plan for Change by addressing challenges mentioned in 'Strong Foundations', 'Kickstarting Economic Growth' and 'Make Britain a Clean Energy Superpower' missions.



HEALTHY NATION

The Healthy Nation tool exists to demonstrate the full capabilities of the Hub. It allows health analysts, the NHS, and other environmental/health data users to explore the potential for use of the DSH to impact health policy, NHS response to environmental changes and planning decisions to build healthy prosperous communities – working towards the UK Government's Plan for Change.

The Hub will draw on data from external (but integrated) and trusted sources such as the UK Health Security Agency and the Environment Agency and allow the visualisation and analysis of real-time data. Examples of these data sets include, but are not limited to, traffic congestion, air and noise pollution levels, and chemical, radiological and nuclear threats.

Whilst also useful for informing long-term planning decisions, this real-time data will also be useful for short-term planning. For example, live data on air pollution will allow NHS trusts to better prepare for an influx of patients arriving to A&E from known triggers like high air pollution levels. By using the Hub to track real-time data in the local area and ensure that staffing levels reflect predicted increases in patients, trusts will be able to become more resilient to shocks and triggers.

DEVELOPING A HEALTHY NATION: USE OF ENVIRONMENTAL DATA IN PREVENTING ILL HEALTH

Professor John Ainsworth

Healthcare is at a crossroads. Ever increasing demand from an ageing population combined with escalating costs of care means the system will become unsustainable. Building a National Health Service that is fit for the future is one of the government's key missions to deliver on over the course of this parliament and beyond. The transition away from a reactive model of care to one that prioritises prevention, is considered by government as one of the three big shifts that will future proof our health service and deliver better outcomes for patients. Underlying traits of a preventative model include averting illnesses before they happen and the earlier identification and management of chronic illness. Such a transition can only occur where consideration is given not just to genes but also the environment as a determinant of health. This places an importance on the availability of environmental data both to public health practitioners from an operational perspective and those who are researching new methods of prevention.

GENES AND THE ENVIRONMENT AS DETERMINANTS OF HEALTH

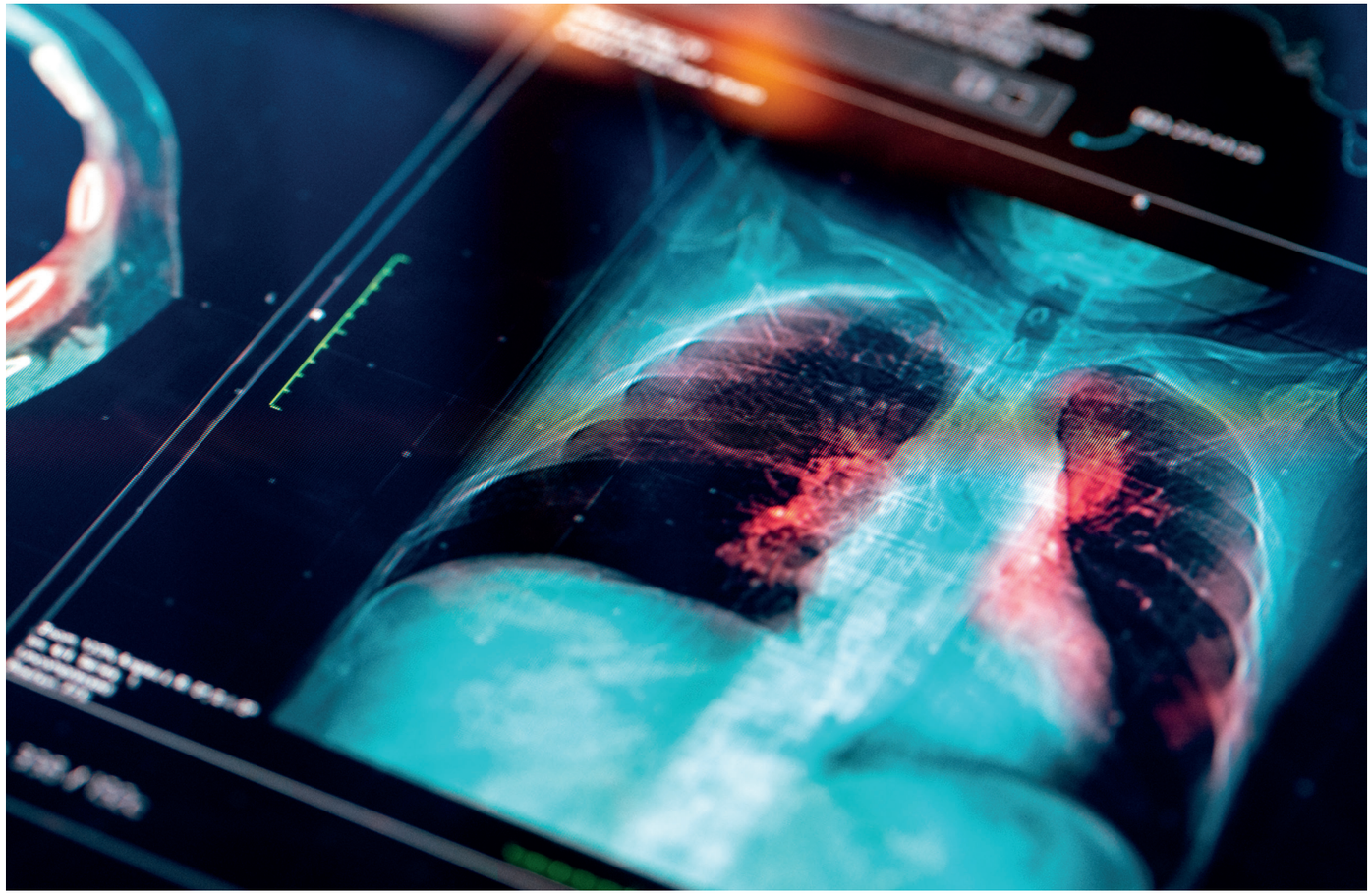
Health outcomes are not solely determined by our genes but also by environmental factors. Non-communicable diseases are often caused by the interaction between genes and lifetime exposure to harm. Harmful exposure could be naturally occurring, such as radon gas, or result from human development, such as air pollution from burning fossil fuels, or through individual choice, such as a sedentary lifestyle, or through deprivation, such as mould in poor quality housing. An individual's risk of developing a disease has two components: the baseline risk determined by their genes and additional risk caused by lifetime exposure to harms. The greater the exposure to those harms, the higher the risk of developing disease. This has been coined the "exposome".

DISEASE PREVENTION

Disease prevention falls into two categories; primary prevention which aims to stop problems developing in the first place by taking actions at population level that eliminate or reduce exposure to harm, and secondary prevention which aims for early detection so that intervention can be employed to stop or delay deterioration in health.

Methods of primary prevention might include the introduction of traffic calming measures in urban areas where there is poor air quality, to reduce pollution levels. For instance, in London, congestion pricing and ultra-low-emission zones have been introduced to reduce the prevalence of harmful pollutants such as nitrogen dioxide and other particulate matter in the air, which has had health benefits for 5 million people living in outer London.

Active transportation, or infrastructure that encourages walking and cycling, is also an example of disease prevention. Research from The University of



By encouraging the take up of active travel, individuals will get the health benefit of more physical activity but also reduces air pollution from vehicles.

Manchester, considers pollution levels around schools, the impact of this on the health of children, and the importance of a community centred approach to active travel policies, so that commuters can use active travel methods to complete their journeys. By encouraging the take up of active travel, individuals will get the health benefit of more physical activity but also reduces air pollution from vehicles.

Access to urban green spaces. Parks, gardens, and green corridors within cities provide residents with spaces for recreation and relaxation and are known to be beneficial for good mental health.

The dominant method of secondary prevention is the use of screening to identify those that have high exposure to harms such as air pollution or long-term exposure to irritants like those from smoking. Such screening, pioneered by The University of Manchester, is now transforming outcomes for patients with lung cancer, after researchers took screenings into communities in a bid to increase earlier detection and improve uptake in those most at risk. This improved detection three-fold compared to the international average.

CHALLENGES WITH PREVENTION

There are several challenges associated with prevention relating to harms caused by environmental factors.

1. IDENTIFICATION OF NEEDS

The genetic revolution has given us one half of the story through things such as the biobank sequencing. However, we need to better understand how genotypes interact with the environment. With progress and innovations being made in this area, this should become more plausible than in the past.

2. COMPETING PRIORITIES

In a system with constrained resources the key question is "where do you get the most improvement for your investment?". Answering this requires taking a holistic view of health and environment and considering the impact of policies that would traditionally sit outside of the health remit, like transport, on health outcomes. For example, if we want to reduce demand in doctors' surgeries what impact would we have by changing traffic policies to reduce air pollution in areas with existing high levels of health deprivation.

3. DATA FRAGMENTATION

Healthcare data, genetic sequencing data and environmental data exist in silos. We need to be able to link them quickly and easily to create a high-resolution picture of exposure and risk.

THE ROLE OF THE DIGITAL SOLUTIONS HUB

One of the key resources available for understanding the impact of the environment on health and prevention is the Digital Solutions Hub, which offers environmental data that can be linked to population-level health data. By leveraging the DSH, researchers can explore issues related to gene-environment interactions and their impact on health. This approach allows for a more nuanced understanding of how environmental context influences genetic predispositions to certain diseases. For example, air pollution is a known factor that affects lung health. By examining the interaction between genetic susceptibility and exposure to air pollution, we can gain a clearer picture of the underlying mechanisms that contribute to respiratory diseases.

To quantify the impact of lifetime exposure to environmental hazards, it is essential to undertake comprehensive population health studies that link health records, genetic data, and environmental exposures. These studies can provide valuable insights into the correlation and causation of environmental factors on health outcomes. The drive towards genomic health service announced in the NHS 10 year plan and the recently announced National Health Research Data Service if linked to the DSH would provide a unique capability to develop new insights into the environment-health-genome interaction.

The DSH will also be useful for those managing service delivery for the NHS, as healthcare providers will be able to monitor, in real-time, local air pollution levels on the Hub. In doing so, NHS trusts will be able to more effectively respond to incidences of poor air quality by ensuring more staff are put on shift for expected increases in admittance to A&E for respiratory problems and become more resilient to shocks and triggers.

POLICY RECOMMENDATIONS

1. The government should invest in large scale population comprehensive health studies that link genetic data, health records, and environmental exposures. This will provide a robust evidence base for understanding gene-environment interactions.

2. Policymakers should utilise resources like the Digital Solutions Hub (DSH) to integrate and analyse data from multiple sources. This will enable more precise identification of environmental risk factors and their impact on health outcomes.

3. Researchers and health practitioners should use the Unique Property Reference Number (UPRN) service to provide the link between an individual's geolocation over time and their environmental exposure to begin to deduce the exposome.

4. Policymakers should develop place-based prevention policies and programmes that enable the 'shift left' to prevention and are delivered digitally using linked environment-health-genomic data.

Policymakers must take a proactive approach to address environmental hazards and their impact on public health, ultimately leading to a healthier and more sustainable future for all.

The relationship between genes, environment, and health is complex and multifaceted. By leveraging digital health data, investing in comprehensive studies, and implementing thoughtful prevention policies, we can create healthier communities and reduce the burden of disease. Policymakers must take a proactive approach to address environmental hazards and their impact on public health, ultimately leading to a healthier and more sustainable future for all. The DSH provides access to a rich data set that can be linked to population level health data to explore issues of correlation and causation around environment and health.

John Ainsworth is a Professor of Health Informatics at The University of Manchester.

HARNESSING DIGITAL SOLUTIONS FOR SUSTAINABLE HOUSING EXPANSION: A GIS-POWERED APPROACH

Professor Richard Kingston

The UK government has committed to an ambitious housing strategy of building 1.5 million homes by 2029 to address the chronic housing shortage exacerbated by rising demand, affordability and population growth. This includes over 100 sites across England being considered for the next generation of new towns. This plan must also rectify long-term structural challenges in the housing market whilst ensuring homes are built sustainably.

While the policy's aims are clear, several challenges remain. Identifying appropriate land for housing requires balancing multiple factors—availability, environmental protection, and infrastructure capabilities. Ensuring access to reliable transport networks, utilities, and public services is critical for creating not just houses but thriving communities. Simultaneously, new housing projects must address climate concerns, minimise carbon footprints and adapt to risks like flooding or biodiversity loss.

The Hub empowers local authorities, planners, and developers to better align housing expansion with environmental, social, and economic goals.

Spatial data, environmental monitoring, and Geographic Information Systems (GIS) can offer cutting-edge solutions to these problems, providing policymakers with tools to make evidence-based decisions on where, how, and when to build. This is where the NERC-funded Digital Solutions Hub (DSH) plays a transformative role. With access to a wealth of environmental data, and the ability to model and visualise complex spatial relationships, the Hub empowers local authorities, planners, and developers to better align housing expansion with environmental, social, and economic goals.

HARNESSING SPATIAL DATA AND GIS FOR STRATEGIC HOUSING DEVELOPMENT

At the heart of the DSH is the capability to gather, analyse, and visualise spatial data. GIS tools, combined with real-time environmental monitoring, offer policymakers insights into the interaction between proposed housing developments and the natural landscape. This can help ensure that housing strategies are underpinned by comprehensive environmental and spatial analysis, leading to more sustainable and efficient outcomes. By integrating future climate change models, policymakers can also assess what developments might look like in 2050, 2060 or even 2070.

LAND SUITABILITY AND ENVIRONMENTAL CONSIDERATIONS

One of the key challenges in housing development is identifying suitable land that supports large-scale construction while mitigating environmental impacts. Through the use of spatial data, the DSH provides detailed information about land use patterns, soil quality, water resources, flood risks, and biodiversity hotspots. This allows planners to avoid ecologically sensitive areas and prioritise locations where environmental disruption can be minimised.

For example, the Hub can generate flood risk maps based on historic data and climate projections, enabling policymakers to assess the long-term viability of a site before breaking ground.

INFRASTRUCTURE AND CONNECTIVITY

Housing developments, and indeed new towns, cannot exist in isolation. They require seamless integration with transportation networks, public utilities, schools, hospitals, and other essential services. GIS-based models, supported by the DSH, provide a clear picture of existing infrastructure and highlight gaps or pressure points that new developments would create.

Using spatial data, planners can map proximity to transport hubs, roads, and green spaces, identifying areas where housing could reinforce local economies and improve social mobility. For instance, planners might focus on sites that have access to public transport, reducing car dependency and contributing to emissions reductions, ensuring that new housing developments are not only liveable but also sustainable and connected to broader urban and regional networks.

SUPPORTING DECARBONISATION AND CLIMATE ADAPTATION

Climate resilience is becoming an increasingly important consideration, as extreme weather events, rising sea levels, and higher temperatures threaten the viability of housing in certain areas. We have already developed the Climate Just mapping tool to understand some of these impacts on different communities at the neighbourhood scale.

GIS technology enables planners to assess the climate risks associated with specific sites and to explore opportunities for integrating renewable energy sources, such as wind, solar and thermal power, into housing projects. The DSH supports this by providing detailed environmental data and models to analyse how different developments interact with energy demand, emissions outputs, and natural carbon sinks like forests or wetlands.

In this way, the Hub facilitates climate-smart planning, ensuring that new homes and towns are built in locations that not only avoid high-risk zones but also contribute positively to the UK's net-zero aspirations.

POLICY RECOMMENDATIONS FOR SUSTAINABLE HOUSING DEVELOPMENT

As policymakers grapple with the challenge of building 1.5 million homes, they must consider a multi-faceted approach that prioritises sustainability, infrastructure resilience, and climate adaptation. These can be addressed in part by decision makers following four criteria:

1. PRIORITISING LAND-USE EFFICIENCY THROUGH DATA-DRIVEN SITE SELECTION

One of the most immediate applications of spatial data is the identification of optimal sites for housing development. Policymakers should work closely with local authorities, developers and researchers to utilise GIS tools – like the DSH– in selecting sites that balance housing needs with environmental protection. Areas with low biodiversity impact, minimal flood risk, and existing infrastructure connectivity should be prioritised, while ecologically sensitive regions should be avoided.

2. ALIGNING HOUSING PROJECTS WITH INFRASTRUCTURE PLANNING

Housing development and new towns should not be seen in isolation from broader infrastructure needs. Policymakers should mandate that new developments are integrated with existing or planned transport networks, utilities, and public services. Using the data from the DSH, planners can better anticipate where infrastructure upgrades are needed and coordinate housing projects accordingly. This will ensure that new developments are not only liveable but contribute to the economic vitality of surrounding areas.

3. INCORPORATING CLIMATE RESILIENCE INTO HOUSING POLICIES

As the UK moves towards its 2050 net-zero target, housing development must be aligned with climate goals. Spatial data can help identify areas where renewable energy can be incorporated into housing projects, whether through on-site energy generation or access to regional renewable grids. Policymakers should develop guidelines that require housing developers to assess and integrate climate resilience measures into their planning, ensuring homes are built to withstand future climate risks while contributing to carbon reduction targets.

The government has a unique opportunity to address the housing crisis while also advancing broader sustainability and climate resilience goals.

4. PROMOTING CROSS-SECTOR COLLABORATION

The success of any housing strategy depends on coordination between government bodies, environmental groups, local communities and the private sector. The DSH is a critical platform for facilitating collaboration between these stakeholders, allowing them to share data, insights, and best practice. Policymakers should encourage ongoing collaboration, creating cross-sectoral partnerships that leverage spatial data to achieve housing targets in a way that is socially, economically, and environmentally sustainable.

The government has a unique opportunity to address the housing crisis while also advancing broader sustainability and climate resilience goals. By leveraging the capability of spatial data and GIS tools, policymakers can ensure new developments are well-placed, well-connected and climate ready. Insights made available through the DSH, can play a pivotal role in ensuring that housing targets are met in a way that balances economic growth with environmental stewardship.

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CLIMATE JUST: SUPPORTING EQUITABLE RESPONSES TO CLIMATE CHANGE THROUGH SOCIAL VULNERABILITY MAPS

Professor Sarah Lindley

CLIMATE IMPACTS: NOT ALL PEOPLE AFFECTED EQUALLY

When we think about climate impacts, we often think about where floods might happen or temperatures peak. Whilst important, this information is only one sort of data needed to understand where the most significant harms might be felt. For example, not everyone is affected by a heatwave in the same way or to the same extent. In some communities there are higher proportions of people who are biophysically sensitive to the impacts of high temperatures due to their age (both the very young and old), their health and/or the medications they are taking. Biophysically sensitive people cannot regulate temperatures as well as other people and are therefore more susceptible to dehydration and heat-stress. However, biophysical factors only explain some of the reasons why people are affected unevenly by climate-related events. There are a range of personal, social and environmental factors to consider, and many can be measured and mapped.

Data are thus imperative in understanding how the severity of impacts might differ between people and communities whilst helping us to understand implications for organisations, service-providers and the systems we rely on. Data are also important in helping with decisions on responses, and ultimately in helping the Government to work towards their Strong Foundations Mission; using data to inform resilience planning for extreme weather events is essential for effective adaptation.

The proportion of people that will be exposed to potentially harmful, and even hotter temperatures, increases every year as global temperatures warm.

Effective adaptation is not a one-size-fits-all solution, but a complex set of responses which need to be tailored to specific – often local – needs. Take social vulnerability to heat for example. In England, 77% of neighbourhoods have typically experienced weather hot enough to lead to detectable excess heat-related mortality. The proportion of people that will be exposed to potentially harmful, and even hotter temperatures, increases every year as global temperatures warm.

Individual, social, economic and environmental factors all affect social vulnerability and can be intertwined. For example, people who are socially isolated have fewer people checking on their wellbeing during hot weather. If they live in rented accommodation, or are on a low income, they may be unable to adapt their homes, such as with shutters or blinds, even if they wish to. If we then consider that some homes, like high rises, do not have gardens or nearby greenspace and tend to overheat, it is clear that additional environmental factors are in play. All of these factors can combine to make the potential for harm particularly acute in some neighbourhoods compared to others. Critically, the most affected neighbourhoods are also often associated with particular social and ethnic groups, leading to questions of social and environmental justice.

Moreover, low incomes affect the ability of people to purchase insurance to protect themselves from losses associated with flooding, and in some communities with high levels of transience and population change there may also be less local knowledge about the extent of flood problems. In these cases, it can be vitally important that support services are in place to improve awareness, provide help and channel resources. Without such actions, inequalities can become persistent with ongoing and long-term impacts on health and wellbeing.

CLIMATE JUST

Originally launched in 2015, Climate Just was updated in 2022 with new data and mapping functions by researchers at The University of Manchester. An online resource and mapping tool, Climate Just enables policymakers, practitioners and council officials to investigate geographical distributions of individual indicators such as age and ill health. Users can also assess composite maps which show population sensitivity, ability to prepare, ability to respond, ability to recover, and factors affecting local neighbourhood exposures, such as building type or the amount of surrounding greenspace.

Taken together, maps of social vulnerability and hazard-exposure give an idea of the distribution of climate disadvantage across parts of the UK at a local neighbourhood level.

Layered on top of these maps are indicators of the potential hazards themselves, such as the potential for flooding or extreme temperatures. Taken together, maps of social vulnerability and hazard-exposure give an idea of the distribution of climate disadvantage across parts of the UK at a local neighbourhood level. Measures of climate disadvantage are important. They account for both the severity of potential climate-related hazards and the individual, social and environmental factors which either increase the potential for harm or offset it. The maps help to differentiate communities where exposure to floods or extreme heat might be similar, but where one community has a greater comparative vulnerability. They identify the sorts of vulnerabilities present, how they are combined and how they compare.

Focussing resources on people and communities who face the greatest potential for harm makes sense. Not only will these people and communities suffer less in the event of a flood or heatwave, but there will be fewer collective burdens on society in the days, months and years which follow. A socially-just response to climate change adaptation is a practical and efficient choice as well as an ethical one.

The new version of the Climate Just map tool has been supported by the Digital Solutions Hub (DSH). Free to use, it provides updated datasets and new functionality. Users can explore our comprehensive, quantitative, and accessible evidence base, case studies and guidance to support more socially-just decision-making. Existing Climate Just data will be integrated into the DSH for users to access alongside over 40 petabytes of other environmental, social, economic and health data that they will be able to search for, visualise and analyse all within the open-access online Hub.

POLICY RECOMMENDATIONS

Local Government Officials, Government Departments and service-providers responsible for – or otherwise supporting - the resilience of our communities should make use of the data available on Climate Just to inform their strategic planning, so that the finite resources available to them are

targeted at the areas of greatest need. This might include supporting investment decisions targeted at more socially vulnerable and climate disadvantaged communities, such as retrofitting of homes so they are fit for future extremes. Organisations responsible for adaptation should also consider partnership with other service providers and support the development of social infrastructure, like community groups and networks.

Policymakers should supplement Climate Just data with local information, further research and other knowledge bases, such as community lived experience. The combination of public and organisational engagement along with the data and tools available on the Climate Just website, should ensure that robust localised solutions are developed which allow for an effective response to future impacts of climate change. For example, NHS England should make use of the Climate Just data, supplemented with their own datasets, to facilitate compliance with the Health and Care Act 2022, as emphasised in the 10 Year Health Plan. This would help ensure that their services are well-adapted to protect vulnerable communities from the effects of extreme weather events by understanding which communities are most vulnerable to flooding or extreme heat events, and how to respond effectively.

The maps and data contained on Climate Just have already proved to be a very useful communication tool helping to bring people together and provide a foundation for fruitful discussion.

It is recommended that all organisations involved in developing adaptations to address social vulnerabilities engage with extended audiences. The maps and data contained on Climate Just have already proved to be a very useful communication tool helping to bring people together and provide a foundation for fruitful discussion. Wider engagement fosters a better appreciation of the wide range of ways that climate change can impact different people in different circumstances and helps to start the conversation with those affected, both directly and indirectly so that actions can be shared and gaps identified that agencies may need to fill.

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The online version of this publication contains links to the sources of evidence cited in the publication. To view this version and see the links, visit: **www.digital-solutions.uk** and **www.policy.manchester.ac.uk/about-us/partnerships**

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Recommendations are based on authors' research evidence and experience in their fields.

Evidence and further discussion can be obtained by correspondence with the authors; please contact **digital-solutions@manchester.ac.uk** in the first instance.

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