FIG GUIDE

FIG PUBLICATION
NO 85

Surveying for Climate Resilience: Practical Climate Actions

FIG Climate Compass Task Force
January 2026

INTERNATIONAL FEDERATION
OF SURVEYORS (FIG)

FIG PUBLICATION NO. 85

Surveying for Climate Resilience: Practical Climate Actions

Author and Coordinator:
Clarissa Augustinus

Contributing Authors:
Uchendu Eugene Chigbu, Charisse Griffith-Charles, Simon Ironside, Eranda Gunathilaka and Rigoberto Moreno Vazquez

INTERNATIONAL FEDERATION OF SURVEYORS (FIG)

International Federation of Surveyors (FIG)
Kalvebod Brygge 31–33
DK-1780 Copenhagen V
DENMARK
Tel. + 45 38 86 10 81
E-mail: FIG@FIG.net
www.fig.net

Published in English

First Edition

ISSN 2311-8423 (pdf)
ISBN 978-87-93914-30-8 (pdf)

Published by: International Federation of Surveyors (FIG)

Front cover images:
Left: Flash Flood in Kathmandu. (Photo-Nakul Shrestha)
Right: Indian tiger crossing Bandhavgarh National Park boundary
into human settlement areas. (Photo courtesy of Paul Augustinus)

Back cover image:
Eugene Chigbu

Author and Coordinator: Clarissa Augustinus

Contributors: Uchendu Eugene Chigbu, Charisse Griffith-Charles, Simon Ironside, Eranda Gunathilaka and Rigoberto Moreno Vazquez

Supported by: Angela Anyakora, David Elegbede, Naa Dedi Tagoe, Cromwell Manaloto, Enrico Rispoli, Maria Scorza, Simon Ironside and Rigoberto Moreno Vazquez.

Layout: Lagarto

CONTENTS

FOREWORD

The world stands at a pivotal moment in its collective response to the climate crisis as a present and accelerating reality. Within this context, the International Federation of Surveyors (FIG) publication *Surveying for Climate Resilience: Practical Climate Actions* – spanning land, water, and marine surveying – highlights the essential role of surveying professionals in advancing climate resilience.

Climate action is a central pillar of the FIG Work Plan 2023–2026 and is deeply aligned with the FIG Vision to "serve and leave no one behind." Sustainability alone is no longer sufficient; resilience must now be embedded in all aspects of our professional practice. As surveyors, we share a responsibility to strengthen knowledge, build capacity, and support people and the planet. It was with this purpose that FIG established the Climate Compass Task Force – to guide our collective efforts and chart a clear path forward.

The scale and complexity of the climate crisis demands that surveyors demonstrate courage, leadership, and a commitment to developing practical, knowledge-driven solutions that enable communities everywhere to thrive. This publication, led by the FIG Climate Compass Task Force, is the product of extensive collaboration across continents, disciplines, and generations and reflects the collective wisdom and commitment of the global survey community.

With its 16 highlevel Climate Actions, this publication marks a significant milestone for FIG. Building on earlier climate publications, it offers practical strategies and realworld examples to support climate adaptation, mitigation, and disaster resilience at national and local levels. Much of the content draws from the rich discussions and technical papers presented during the FIG Working Weeks from 2023 to 2026. Including a significant contribution from the Call to Action on Climate Responsible Land Governance and Disaster Resilience (2024, Nepal Regional conference).

The evidence is clear: surveyors are on the critical path to delivering climate resilience globally, nationally, and locally. Our profession's core strengths – precision, integrity, and a commitment to authoritative data – are more vital than ever as we confront the escalating impacts of climate change.

Digital technological innovations are reshaping how surveyors collect, manage, and interpret data, providing insights for climate action and helping to bridge the digital divide between the Global North and South. Yet embracing these technologies brings responsibilities: upholding ethical standards, protecting data sovereignty, and respecting Indigenous and local community rights. The profession is also evolving within emerging climate resilience markets, such as by the integration of climate data with land administration systems and developing interoperable platforms for informed responses. Surveyors' contributions – such as redesigning geodetic and hydrographic infrastructure and advancing scenario modelling – are vital to ensuring that systems remain fit for climate resilience.

These evolving roles demand new ethical standards and protocols. As experts in the relationship between land and people, surveyors play a critical role in safeguarding land rights – particularly for vulnerable populations – while supporting adaptation and mitigation strategies. This involves making informed judgements on rights, restrictions, and responsibilities, with a renewed commitment on fairness and equity. Meeting these challenges requires expanding the workforce, fostering interdisciplinary collaboration, and empowering young and diverse professionals to lead future efforts.

I extend my sincere appreciation to all who contributed to this publication. I express my deepest gratitude to Dr Clarissa Augustinus, Chair of the Climate Compass Task Force, who served as lead author and coordinator. Her leadership, together with the dedication of the Task Force team and the many reviewers whose insights covering the many aspects of surveying and drawn from every region of the world, has ensured that this guidance is both globally relevant and locally actionable.

The future we seek is one that fully supports the United Nations Sustainable Development Goals – advancing People through responsible land governance, strengthening Partnerships from global to local, promoting Peace through equity and human rights, protecting our Planet from the impacts of climate change and natural disasters, and enabling Prosperity through resilient land and property systems.

Let this report serve as both a call to action and a source of inspiration to the global FIG community. Together, we can harness the power of surveying to build a more resilient, equitable, and sustainable future for all.

Diane A Dumashie,
FIG President (2023–2026)

ACKNOWLEDGMENTS AND REVIEW PROCESS

Many people from the wider FIG community contributed to this publication, aside from the Contributing Authors who played a large role. The reviewers are acknowledged leaders in their various surveying fields. As climate issues can be highly contextual and to ensure global relevance, reviewers are from Africa, Asia, Europe, North America, South America, the Caribbean and the Arab region. They include highly respected professionals such as: Assistant Professor Bernardo Ribeiro de Almedia of the Leiden University College and Van Vollenhoven Institute; Professor Jagannath Aryal of the Department of Infrastructure Engineering at the University of Melbourne, Australia; Dr Grenville Barnes, Emeritus Professor at the University of Florida and land tenure and cadastral consultant; Associate Professor Rohan Bennett, Chair of FIG Commission 7 on Land Management and Cadastre; Rafic Khouri, Advisor to the President for International Development, Union of Arab Surveyors; Dr. David Mitchell, consultant surveyor specialising in land tenure, disaster risk reduction and climate vulnerability particularly in the Pacific, Melbourne, Australia; Professor Ruishan Chen, School of Design, Shanghai Jiaotong University, Shanghai, China; Melissa Retana Sanchez, Land Surveyor, Costa Rica; Dr Mohamed Timoulali, GTOPIC, Morocco. Some reviewers only focused on their areas of interest such as: Peter Ache, Chair of FIG Commission 9 on Valuation and the Management of Real Estate; James Kavanagh, Global Director of Land, Professional Groups and Forums Department, Royal Institution of Chartered Surveyors (RICS); Mike McDermott, International Valuation Consultant. This publication was also reviewed either in whole or in part by international organizations and reviewers included Sasha Alexander, United Nations Convention to Combat Desertification; and John Gitau, UN-Habitat/Global Land Tool Network.

EXECUTIVE SUMMARY

Purpose and approach: The purpose of this FIG publication has been to identify some of the key surveying actions, methods and tools for climate resilience, for land, water and marine environments, for people, economic growth/poverty reduction and the planet. FIG papers, presentations at conferences and Climate Compass Task Force webinars were the main source of information for this publication. They also informed the choice of the 16 Climate Actions highlighted. Prominent surveyors in the profession gave detailed comments on advanced drafts and supplied overall and detailed guidance. This strengthened the publication and confirmed the major climate resilience roles for surveyors.

Photo 1: *FIG organises a large event every year. Every four year the larger FIG Congress which marks the final year of the FIG leadership team, and in the years between FIG Working Weeks with technical sessions and sessions/meetings organised by FIG Commissions, Networks and Task Forces. The Climate Compass Task Force was established in 2023 for a 4-year term and in each Working Week topics around Climate Action have been central to the conferences.*

Long-term geospatial, hydrospatial and land administration systems data collection are foundations for territorial governance, in the context of climate resilience. This data is vital for: climate-related policy development; long-term climate monitoring and management; and the identification of risks. It supports planning for: adaptation (adapting to manage climate impacts) and mitigation (reduction or prevention of greenhouse gases including carbon); effective land, water and marine management; and support to decision-makers managing the climate crisis. New technologies such as geospatial databases, Earth Observation (EO) data, artificial intelligence (AI) tools, and other spatial and temporal innovations have made the surveyors' role critical in the management of climate impacts. Climate action is becoming an increasingly key feature of FIG. Sixteen (16) critical Climate Actions are identified in this publication for surveying for climate resilience.

Definition of climate resilience: Surveying for climate resilience involves re-designing geospatial data systems, geodetic and hydrographic infrastructure, database systems and land administration systems, policies, methods and tools, to address the challenges of climate change (carbon emissions), biodiversity loss, and land degradation. It focuses on managing climate impacts, adapting to climate change, and transitioning to sustainable practices that support carbon emissions reduction (mitigation) on land, and in water and marine environments. This will contribute to ensuring resilience for both people and the planet.

Climate crisis, vulnerable people and new business models: Humanity is dealing with a global climate crisis, with disproportionate impacts on vulnerable regions, countries and people in the global south. The most affected populations are often those with insecure tenure, including smallholder farmers, local communities, informal settlers, women and those living in disaster prone areas. Surveyors have a major role to play supporting the adaptation and mitigation of climate impacts at the global, national and local levels in a way that supports environmental sustainability, economic growth and the land rights of people. The 17 Sustainable Development Goals form the overarching policy framework for this publication.

The climate crisis is creating opportunities for surveyors, government, the private sector and industries to move to new business models that support climate resilience. To encourage surveyors to develop solutions, some of the key actions, methods and tools of these business models, across the digital divide, are described.

New technology, quality assessment, ethics: New and complex climate challenges can be addressed by embracing new technology. New technology allows professionals to focus on data interpretation, analytics and the extraction of meaningful climate related insights, rather than data handling. Surveyors need to continue to develop, redesign, field test, innovate, experiment and pilot novel procedures using new technology, including artificial intelligence (AI), to meet the new demands regarding climate resilience. Using new technology to support climate resilience requires new types of ethical judgements and standards.

Government, customers and users: New markets are opening for surveyors. Customers, users and government will need ongoing support as they respond to climate resilient market trends, regulatory requirements and disclosure standards. Government-led climate action involves collaboration and coordination in a whole-of-government approach to support the delivery of national environmental goals and plans, where the Lands Departments have a key role to play.

Education, training and workforce: While some education and training institutions have already taken up the challenge of educating surveyors to support climate resilience, much more needs to be done, also regarding continuing professional development (CPD). Also, immediate efforts are needed to scale up the workforce to support climate resilience, focused on the surveyor's role as data manager, young surveyors and women surveyors.

Land and marine cadastre and data: The climate crisis has started facilitating the development of innovative fit-for-purpose (FFP) systems that support climate resilience. FFP land administration systems, data, tools and methodologies are being re-designed for climate resilience. Geodetic and hydrographic infrastructure are key to the protection and management of the marine environment and for strengthening marine cadastres.

Urban and rural areas: Surveying that supports climate resilience in urban areas needs to address a wide range of issues including: blue-green infrastructure; urban sprawl into agricultural and natural areas; affordable housing shortages; large scale climate induced migration to urban areas requiring increased land; smart land use planning and services; the rehabilitation and redevelopment of infrastructure after natural disaster events; and vulnerable informal settlements. In rural areas, climate smart agriculture, environmentally sustainable land use practices and forest management need to be supported by surveyors, as land use change is directly linked to large scale carbon emissions.

Natural disaster and climate-related conflict: Surveying knowledge and skills are needed to address a wide range of different types of natural hazards and disasters. Climate-related disasters displace millions of people every year as their homes become uninhabitable, their livelihoods unsustainable and their lives at risk in hazard-prone areas. The land rights of vulnerable people need to be protected. Geospatial and land administration systems need to be re-designed for the different natural disaster stages. Climate, conflict and land are often inter-linked. Conflict can exacerbate climate issues and climate issues can trigger conflict, including violent protracted conflict. It can cause people to migrate, compete for land, water and natural resources, and struggle for food security.

International organizations: Surveyors are asking for practical examples of climate resilient surveying, rather than policy directions alone. International bodies who want to engage in climate action and surveying should take cognizance of this as they work to support people and the planet.

Overall findings: Surveyors undertake many critical climate actions, often involving multiple stakeholders. While governments play the leading role, the private sector, academia, national and international institutions, training institutions and those industries building new geospatial data, analytical methods and tools, are also key to surveying for climate resilience. Climate action involves technology, governance and people, which in the climate context also means safeguarding people's land rights and livelihoods.

To support the climate resilience of people and the environment, surveyors are adapting professional standards. As new technologies and processes emerge, quality assessment, testing and developing new data acquisition tools are key. This is something for which surveyors are well known and it is vital for sustainability both in terms of system design and for climate resilience. This also means adopting and adapting AI and machine learning, guided by the reasoning of surveyors for accuracy. Most importantly, government-led programmes on climate resilience are critical for success and scale. As governments strive to meet national environmental, economic, social and governance goals, surveyors can support decision-makers to make better decisions. Customers, existing and future, need support as they include climate adaptation and mitigation in their business models.

To ensure that the surveying industry can do the job, surveying education, training and continuing professional development needs to be re-geared along a spectrum from digital literacy to advanced analytics to support the development of surveying for climate resilience. This is required so that the work force can upscale and undertake the required climate actions locally, nationally and for the planet.

All of this work underpins the re-design of the land administration and geospatial data systems to support climate resilience. Rapid, agile, climate resilient FFP land administration is needed to support disaster and conflict risk management. Urban and rural land administration systems are being re-designed to prevent urban encroachment on adjacent agricultural and natural areas and agricultural encroachment on natural areas and forests. A much greater focus is needed on forests than has been traditional among surveyors.

Significant challenges remain: While this practical guide draws on case studies, best practices and activity highlights that show the way forward to support climate resilience, major challenges remain. There are numerous gaps in actions, tools and methods that need to be scaled, as only some countries have working solutions. Or the solutions are only being addressed in some countries in the global north. Or solutions are context specific and need to be documented and shared to other countries for domestication. Or they reflect goals still being worked on at country and local levels. The tools, methods and actions described here need to be scaled up dramatically within countries and across the world.

The 16 Climate Actions: This publication is structured in terms of 16 Climate Actions. The first 9 Climate Actions are about the fundamentals of all professional surveying for climate resilience namely: Climate Action 1. Professional ethics and standards; Climate Action 2. People, surveying and governance; Climate Action 3. Testing and developing new data acquisition tools; Climate Action 4. Increasing technical capacity, including AI use; Climate Action 5. Quality assessment; Climate Action 6. Government-led response to climate issues, including local government; Climate Action 7. Customers and users of surveying for climate resilience; Climate Action 8. Education, training and continuing professional development; and Climate Action 9. Scaling up the work force.

This is followed by 6 Climate Actions that focus on types of situations where surveying for climate resilience would be mainly carried out namely: Climate Action 10: Rapid, agile, climate resilient fit-for-purpose land administration; Climate Action 11: Strengthening marine data systems; Climate Action 12: Re-designing urban and peri-urban systems for climate resilience; Climate Action 13: Sustainable rural land management; Climate Action 14: Disaster risk management; and Climate Action 15: Climate, conflict and land. The final Climate Action relates to international players namely: Climate Action 16: Role of international surveying bodies.

International Federation of Surveyors (FIG): FIG as a large international organization covering over 100 countries has made a good start on branding the profession as playing an important climate action role. This is demonstrated by the increasing number of climate-related abstracts being submitted for the annual Working Week or quadrennial Congresses. This aspect of the FIG brand needs to be strengthened to reach humanities' environmental goals faster and at the scale required.

Use of AI: No AI was used to create the contents of this publication. Readers are however encouraged to use AI to summarise this publication in terms of their own interests if they have insufficient time to read the whole publication.

1 INTRODUCTION: SURVEYING FOR CLIMATE RESILIENCE: PRACTICAL CLIMATE ACTIONS

1.1 Surveyors and the climate crisis

Humanity is dealing with a global climate crisis, with disproportionate impact on vulnerable regions, countries and people in the global south. The most affected populations are often those with insecure tenure, including smallholder farmers, Indigenous People and Local Communities (IPLC), informal settlers, women and those living in disaster prone areas and in areas of conflict. Vulnerable populations are experiencing the loss of land due to environmental degradation because of rising sea levels, desertification, land degradation, deforestation, natural hazards and disasters. Land conflicts are increasing because of competition over resources, land grabs and exploitation leading to forced displacement and migration, amplified by the climate crisis and disasters.

Often resettlement programmes are inadequate. The customary land tenure systems of local communities are being eroded and disrupted, including those of smallholder farmers and pastoralists. All of this is impacting the livelihoods of poor people causing a decline in agricultural productivity and shifts in livelihoods. Government-led climate projects and land use changes designed for climate adaptation can have unintended negative consequences on vulnerable occupants, if not designed to take into account the issues of local people. Often countries lack climate-responsive policies, land laws and regulations to protect the land rights of vulnerable communities particularly where governments prioritise economic growth. Even where policies do exist, they are often not implemented. Surveyors have a major role to play supporting the adaptation and mitigation of climate impacts at the global, national and local levels in a way that supports climate goals and environmental sustainability, economic growth and the land rights of people.

The purpose of this FIG publication has been to identify some of the key surveying actions, methods and tools for climate resilience, for land, water and marine environments, for people, economic growth/poverty reduction and the planet. FIG papers, presentations at conferences and Climate Compass Task Force webinars were the main source of information for this publication. They also informed the choice of the 16 Climate Actions highlighted. Prominent surveyors in the profession gave detailed comments on advanced drafts and supplied overall and detailed guidance, text, graphics and photographs. This strengthened the publication and confirmed the major climate resilience issues for surveyors.

Long-term geospatial, hydrospatial and land administration systems data collection are foundations for territorial governance, in the context of climate resilience. This data links the physical, legal, economic and environmental dimensions of land, water and marine. This data provides vital information for:

- Climate-related policy development;
- Long-term climate monitoring and management;
- Identification of risks;
- Adaptation and mitigation measures;
- Effective land, water and marine management;
- Support to decision-makers managing the climate crisis.

New technologies such as geospatial databases, historical and current Earth Observation (EO) data, large time series data analysis, AI tools, and other spatial and temporal innovations have enhanced the surveyors' critical role in the management of climate impacts. Climate action is one of the priority global issues for the members of FIG and this publication is structured around sixteen (16) critical Climate Actions that reflect the priority contributions of surveyors to the climate crisis (see Figure 1 below).

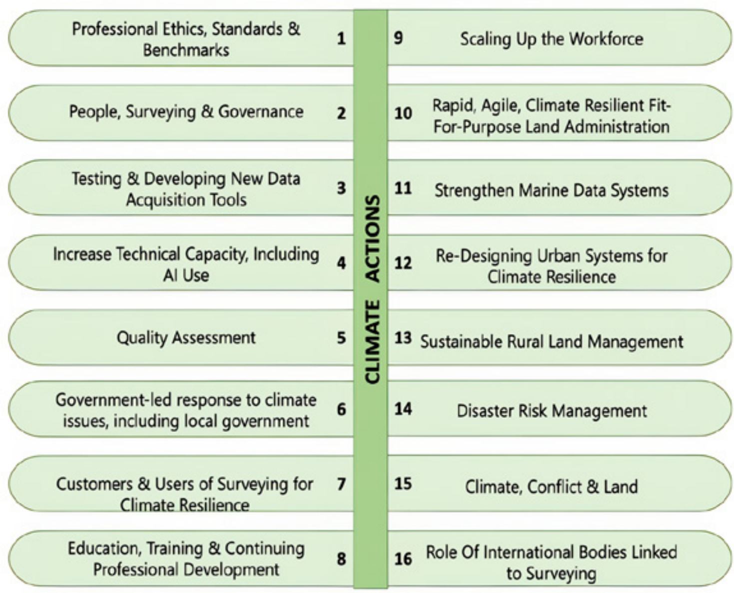


Figure 1: *The 16 Critical Climate Actions of Surveyors, 2025.*
Graphic courtesy of U.E. Chigbu

Analysis of conference papers and presentations at recent FIG events highlights that surveyors are on the critical path of most large climate action projects. They increasingly apply their measurement and spatial data analysis skills in support of climate resilience (see definition below), while supporting the objectives of the Sustainable Development Goals (SDG), which form the overarching policy framework for this publication.

Definition: Surveying for climate resilience involves re-designing geospatial data systems, geodetic and hydrographic/hydrospatial infrastructure, database systems and land administration systems, policies, methods and tools, to address the challenges of climate change (carbon emissions), biodiversity loss, and land degradation. It focuses on managing climate impacts, adapting to climate change, and transitioning to sustainable practices that support carbon emissions reduction (mitigation) in land, water and marine environments, thus ensuring resilience for both people and the planet.

Photo 2: *Land degradation. Photograph courtesy of Paul Augustinus.*

The climate crisis is creating opportunities for surveyors, government, the private sector and industry to move to new business models that support climate resilience. There needs to be more investment in geodetic, geospatial and hydrographic/hydrospatial infrastructure to increase climate resilience. Some of the key actions, methods and tools associated with these business models are described in this publication. They apply to differing contexts and are dependent upon surveying capacity (human and financial) at the national and local level, time budgets and quality requirements.

The Chair of FIG Young Surveyors, Shirley Chapunza calls surveyors to action, saying that "As surveyors we are positioned at the forefront of addressing some of the most pressing challenges around climate change and sustainable land use. Let us collaborate and lead with purpose, ensuring that the future we build together is one that thrives for generations to come."

Surveyors are encouraged to use this publication to innovate and develop new business models that support climate resilience using new technology and insights to develop solutions for tomorrow. These solutions need to cross the digital divide of the global north and global south. They need to simultaneously support environmental goals and economic growth/ poverty alleviation goals and consider their impact on people, including the poor.

1.2 Beyond business as usual

Many surveyors in the industry have traditionally supported the USD287.6 trillion global residential real estate market, with a relatively small but high-profile grouping involved with the pro-poor aspects of tenure security and governance. The development of new surveying business models for climate resilience is now a growing industry able to support multiple workflows which involve going beyond business as usual. Surveyors use of geospatial technology is evolving rapidly to meet climate and disaster challenges, also as there are new markets for their skills. A variety of approaches are emerging including:

1. Business as usual surveying without applying technological advancements suited to the context of climate change adaptation and mitigation.
2. Integration of climate data with land administration data, with in some cases interoperable systems (for example land and disaster) to inform climate

responses. Some of this work involves just data/information provision and/or integration, such as into the National Spatial Data Infrastructure (NSDI). Other workflows have a clear climate strategy supported by EO and Information Technology (IT) applications, such as those linked to property rights and carbon accounting platforms. This latter work goes beyond data collection/integration and monitoring and evaluation. Important roles include developing climate resilient cadastral, planning, valuation, positioning, NSDI and land management systems.

3. Independent measurement, monitoring and assessment of climate-related issues is an emerging frontier for surveyors- leveraging the profession's precision, technical expertise, and trusted credibility (see examples below). Increasingly global and national mapping efforts are linked with geospatial technologies used to understand and manage interactions within earth systems. These linkages can strengthen climate action and environmental sustainability efforts. An increasing number of abstracts submitted for the recent FIG Working Weeks covers these types of areas of work as surveyors utilise a wide variety of measurement approaches and tools to support climate resilience.

Examples of stand-alone measurements for climate resilience: *1) flooding (Punjab, Pakistan); 2) carbon estimation; forests/deforestation/reforestation (the Amazon); 3) fires (Italy); 4) land-slides (Nepal); 5) earthquakes and deformation; 6) land use and land use change (LUC) and habitat characteristics (Portugal, Kenya); 7) land degradation, drought and desertification/restoration; 8)wetland preservation; 9) patterns of ground water re-charge; 10) food productivity; 11) mapping pollution in the ocean; 12) sea level rise and coastal zone management (Caribbean); 13) hurricanes (impact on electric grid in Mexico); 14) green and blue infrastructure; 15) waste management; 16) sewage disposal; 17) invasive species and native vegetation management; 18) heat islands and utilities management (Nigeria); impact of mining on surrounding areas (Botswana).*

1.3 Methodology

The 16 Climate Actions described in this publication are based on the presentations, papers and discussions (2022–2025) by the global FIG surveying community describing practical climate actions to address the climate crisis. These are described in 16 high level Climate Actions grouped by fundamental aspects of surveying for climate resilience; focus areas for climate action; and international roles.

This publication is mostly based on presentations and papers from the FIG Working Weeks in Orlando (2023); Accra (2024); Brisbane (2025); abstracts for the Cape Town Congress (2026); the FIG Regional Conference in Nepal (2024); the UN-Habitat/Global Land Tool Network 3rd Arab Land Conference in Morocco (2025); Climate Compass Task Force events, webinars and seminars; and to a lesser extent from GIM magazine articles. Academic literature and the GIM magazine articles also contributed to the identification of the challenges.

Photo 3: *Delegates, participants, and representatives from across the globe gathered at the Conference on Climate Responsible Land Governance and Disaster Resilience: Safeguarding Land Rights, FIG Regional Conference, 2024, in Nepal. Photograph courtesy of Government of Nepal.*

Prominent surveyors in the profession have also given detailed comments on advanced drafts which were used to strengthen the publication and confirm the 16 Climate Action summaries. Reviewers also contributed text.

Given the wide range of work undertaken by FIG in many countries, and across all its 10 Commissions, it is not possible to capture and integrate all the climate action work being done and all the detailed knowledge and climate related contexts that surveyors are working on at the national and local levels. Instead, this is a high-level overview of key actions, methods and tools that surveyors are using to support climate resilience across the FIG Commissions and Task Forces.

This does not mean that surveying for climate resilience has been scaled sufficiently across the globe, but rather that the work of developing solutions is happening, and needs to be suitably upscaled. While this practical guide draws on case studies, best practices and activity highlights that show the way forward to support climate resilience, significant challenges remain. There are numerous gaps in actions, tools and methods that need to be scaled, as only some countries have working solutions. Or the solutions are only being addressed in some countries in the global north. Or they are context specific solutions which need to be documented and shared to other countries for domestication. Or they reflect goals currently being worked on at country and local levels. The tools, methods and actions described here need to be scaled up dramatically within countries and across the world.

Many land administration and geospatial systems have not yet been re-designed for climate resilience putting people, economies and the environment at risk. Coordination across government, involving for example Lands Departments with the environmental sector, is not yet robust. This means that financial capacity and the ability to access green funding is a key constraint. The digital divide between the global north and south can be a key constraint. There are very few opportunities for surveyors, particularly in the global south, to be trained in climate resilience. This would be a key step. To expand the workforce more surveyors need to move from data collection to data management enabled by the new technology. These are just a few of the main challenges. Some of these challenges are noted in the Climate Action sections below as a reminder that much work still needs to be done. The target audience of this publication are the whole range of professionals within the global surveying community, with a focus on professionals working at national and local levels.

While the material is drawn from case studies and use cases, these are not presented. Instead, these can be found in the hyperlinked papers in the FIG technical programmes for each conference and can be found on the FIG website. These papers give a very rich and detailed set of cases on surveying for climate resilience, across the Commissions and in a wide variety of contexts.

In summary, the first 9 Climate Actions focus on the fundamentals of all professional surveying for climate resilience namely:

- Professional ethics and standards;
- People, surveying and governance;
- Testing and developing new data acquisition tools;
- Increasing technical capacity, including AI use;
- Quality assessment;
- Government-led response to climate issues, including local government;
- Customers and users of surveying for climate resilience;
- Education, training and continuing professional development;
- Scaling up the work force.

This is followed by 6 Climate Actions focussing on situations where surveying for climate resilience is mainly found namely:

- Rapid, agile, climate resilient fit-for-purpose land administration;
- Strengthening marine data systems;
- Re-designing urban and peri-urban systems for climate resilience;
- Sustainable rural land management;
- Disaster risk management;
- Climate, conflict and land.

The final Climate Action is about the 'Role of international surveying bodies.'

No AI was used to create the contents of this publication. Only one of the many reviewers used AI (co-pilot). Readers are however encouraged to use AI to summarise this publication in terms of their own interests if they have insufficient time to read the whole publication.

2 SURVEYING FUNDAMENTALS AND CLIMATE RESILIENCE

The nine Climate Actions in this section focus on the fundamentals of surveying for climate resilience. These are: Climate Action 1. Professional ethics and standards; Climate Action 2. People, surveying and governance; Climate Action 3. Testing and developing new data acquisition tools; Climate Action 4. Increasing technical capacity, including AI use; Climate Action 5. Quality assessment; Climate Action 6. Government-led response to climate issues, including local government; Climate Action 7. Customers and users of surveying for climate resilience; Climate Action 8. Education, training and continuing professional development; and Climate Action 9. Scaling up the work force.

2.1 CLIMATE ACTION 1: PROFESSIONAL ETHICS AND STANDARDS

Surveyors are known for their professionalism, ethics, respect for legality, accuracy, compliance, precision and measurement skills. They represent in two, three or four dimensions what is on the ground with minimal error and produce authoritative and informative data from it. This expertise puts the surveyor at the forefront of robust climate action. The use of new technology to support climate resilience requires new types of ethical judgements and protocols, including international, national and local standards.

2.1.1 Frameworks

1. Strengthen professional ethics and standards. New technology and the need to respond with rapidity and agility to climate and natural disaster crises places more responsibility on the surveyor to:
   i. manage and protect data;
   ii. assess different options;
   iii. protect the environment and people’s land rights.
2. Develop new geospatial data sharing policies supported by the legal frameworks to facilitate multi-agency collaboration for more effective decision-making and climate action.
3. Respond to evolving climate-related legislation, regulations, standards and disclosure requirements.
4. Create and formalise climate resilient FFP standards, including geospatial data interoperability and rapid data acquisition standards. This has implications for legal systems, standards, spatial frameworks and technology.
5. Re-design surveying systems for climate adaptation and mitigation that delivers the best outcomes for vulnerable people and communities. Ensure that technical innovation and new systems do not increase risks to people and vulnerable populations.
6. Avoid developing stand-alone FFP projects or new systems that are not sustainable once the project is complete. Instead consider starting with minimum standards that are upgradeable within the legal framework(s).

2.1.2 Specific standards

1. Develop and embed new standards within targeted industries, such as mining, and/or within a NSDI or other government systems. Develop industry-wide standards including international system comparisons (for example Open Geospatial Consortium (OGC)) standards on climate.

2. Design applications linked to the International Organization for Standardization ISO/TC 211, including fast tracked standards where implementation is ready as the standard goes to publication. This is key for data sharing across communities of users. It enables members of the geospatial community to ensure their data harmonizes with other data within their domain and across domains and jurisdictions. This approach can also be used for cross-boundary climate actions.

3. Adapt ISO 19115 Metadata and ISO 19157 Data quality standards for climate action. Use open standards that support Findable, Accessible, Interoperable and Reusable (FAIR) data use (ISO-TC 211).

4. Manage transparency issues around the sourcing of spatial data, modelling, public domain data, privacy, legal and professional requirements and cybersecurity issues. Be aware of governance requirements around 'what data is needed for whom.'

2.1.3 Standards and people

1. Build ethical capacity and resilience into dealing with conflicts over natural resources, land, water and the marine environment. Balance the needs of people with global environmental goals for the future of humanity and economic growth/poverty reduction goals.

Photo 4: *Indian tiger crossing Bandhavgarh National Park boundary into human settlement areas. Photograph courtesy of Paul Augustinus.*

2. Strengthen climate action standards relating to 'Rights, Restrictions and Responsibilities' in land, which involves the protection of the land rights of vulnerable communities affected by climate impacts. This involves both the wise

use of incompatible land use practices, and re-assessing climate risk to protect people, the environment and the economy.

3. Create specific standards and protocols for spatial data use in sensitive locations, such as Indigenous territories and protected natural areas. Incorporate the principle of data sovereignty into climate management where data generated by local communities remains under their control.

2.1.4 Challenges

1. New climate-related judgements are needed to ensure land-related 'Rights, Restrictions and Responsibilities' obligations are followed, as the profession is challenged to develop new land, water, marine, natural resources and carbon business models to support climate resilience, including the allocation of carbon credits.
2. Keeping up to date with new technology and using it to address the more complex problems emerging, and within an ethical framework is not easy, either in terms of capacity or finances.
3. Issues related to climate-related data transparency for a range of stakeholders, including vulnerable people, is a key issue that needs more attention.

2.2 CLIMATE ACTION 2: PEOPLE, SURVEYING AND GOVERNANCE

Climate change has a disproportionate impact on low-income communities around the world, the people and places least responsible for the problem. Surveyors should support governance and climate justice. Surveyors can provide rigorous positioning frameworks and the authoritative data needed to support effective location-based climate resilient solutions and address equity issues linked to social, racial and environmental injustices.

2.2.1 Tools and methods

1. Weigh the impact of surveying for climate resilience actions, tools and methodologies and their effect on people, particularly vulnerable populations.
2. For decision-makers, use geospatial data, statistics and modelling for the design of cost-effective scenarios to weigh the opportunities and risks of policies, programs and projects for 1/economic growth/poverty alleviation, 2/protection of the environment, and 3/people, (see Figure 2 below). Governments are setting these 3 as national goals to be achieved simultaneously (Brazil, South Africa, Indonesia). Surveyors' work currently contributes to all 3 of these, although not necessarily at the same time. Using spatial data to analyse the 3 simultaneously is being scaled up, through the analysis of large datasets for climate action scenario development. Surveyors need to be more actively involved to increase its usefulness.

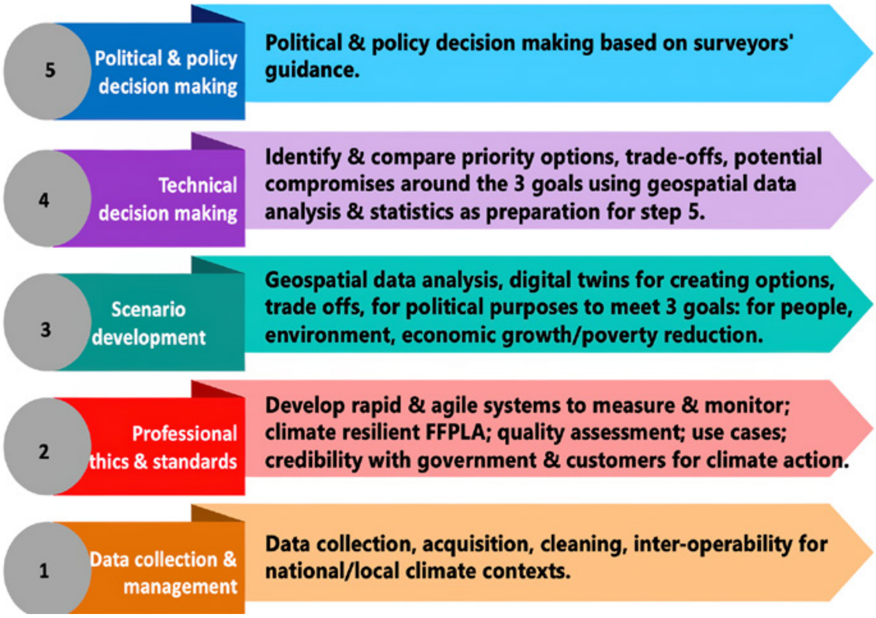


Figure 2: *The surveyors' role in decision-making to achieve national goals – environment, economic and people. C. Augustinus and D. Dumashie, 2024, Linkedin. Graphic adapted by and courtesy of U.E. Chigbu, 2025.*

3. Surveyors can contribute a range of skills and knowledge to facilitate such scenario development including:

   i. professional ethics;
   ii. measurement, monitoring and verification skills;
   iii. technical and innovation capacity;
   iv. climate modelling;
   v. testing new use cases and developing tools;
   vi. development of rapid and agile systems;
   vii. building climate resilient FFPLA systems;
   viii. quality assessment capacity;
   ix. a focus on standardisation;
   x. risk management;
   xi. credibility with government and other customers and users of surveying services;
   xii. support to national, regional and local government-led climate actions;
   xiii. the role of international surveying bodies advising on best practice.

4. Strengthen policy and legal frameworks, administrative procedures and capacity to ensure climate-responsive land governance, geospatial data governance and environmental governance in the face of climate change. Protect and help to strengthen IPLC land and natural resource rights and their access to Payment for Ecosystem Services (PES). This includes through:

   i. government led policy and legal reforms;
   ii. multi-stakeholder strategies in the short, medium and long term;
   iii. equity and rights recognition (for example Free Prior and Informed Consent (FPIC));

iv. responsible governance;
v. participation;
vi. benefits;
vii. financing mechanisms.

5. Align the adoption of AI in surveying for climate resilience with ethical principles and territorial data sovereignty. AI should contribute to strengthening territorial rights, equity, and climate governance, and not to generating new information asymmetries, exclusion, or technological dependence. Data generated or used in the territories of IPLC must be managed responsibly, respecting the principles of FPIC, community control, and the ethical use of information.

6. Build the capacity of regional and local governments to implement land management that supports climate resilience and protects the land rights of vulnerable people affected by climate change.

7. Train IPLC people and vulnerable communities in the use of tools for climate action, particularly in the global south, and promote an inclusive approach to capacity building. Empower these communities, raise awareness and increase their geospatial literacy about environmental issues. Foster ownership and encourage active participation in environmental protection initiatives.

8. A wide range of land management approaches are needed for people and climate action (see examples below).

Examples of land management approaches: *1) land rights in forests; 2) geospatial analysis of land tenure and land use patterns; 3) grassroots and local communities disaster management; 4) community mapping for sustainable development; 5) geospatial data in Small Island Development States (SIDS); 6) documenting the land tenure of small scale farmers to improve environmental protection; 7) demarcating forest boundaries; 8) demarcating game reserve boundaries and biodiversity corridors; 9) participatory and model-based land management for climate-adaption and development in high risk areas; 10) carbon offset projects.*

2.2.2 Challenges

1. Climate change and climate induced disasters are a threat to the security of tenure, land rights and livelihoods of vulnerable communities.

2. There is a lack of land law and implemented regulations to manage the impact of climate change on vulnerable communities.

3. There is often weak tenure security with little or no land information about IPLC people, women and informal settlers/temporary residents land rights, thereby undermining the ability to address environmental impacts and challenges.

4. Most climate projects are being undertaken without reference to the land administration system, which is likely to impact sustainability, scalability and people's land rights. Climate projects need to be linked to the land administration system, such as the large scale internationally funded climate projects known as Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD+) projects.

5. Climate adaptation and mitigation projects, such as solar panels, forest conservation or infrastructure projects, can exacerbate the competition over land and affect vulnerable communities.

6. Climate and land governance is insufficiently linked at national and local levels and during the implementation of projects.
7. Regional and local governments often lack the capacity to implement land management approaches (see examples above) that support climate resilience and protect the land rights of vulnerable people affected by climate change.

2.3 CLIMATE ACTION 3: TESTING AND DEVELOPING NEW DATA ACQUISITION TOOLS

Surveyors develop and use software and associated tools that enable reliable geodata analysis critical for monitoring, mitigating and adapting to climate change. They also develop data dissemination tools that increase the accessibility of climate-related data, build new data standards and new business processes. Surveyors need to continue to develop, re-design, test, innovate, experiment and pilot novel procedures using new technology to meet evolving climate resilience demands.

Re-design involves the use of existing, new and evolving technology for increased efficiency and addressing the additional complexity associated with climate uncertainty. Complexity will increasingly define risks and opportunities. It will motivate surveyors to move beyond hierarchical and linear thinking to new forms of systems thinking (both for new and existing systems). Re-design will be required for the management of distributed climate actions for a range of stakeholders and ecosystems of data involving government, private sector, academic, non-government and citizen roles.

2.3.1 Tools and methods

1. Adapt tools and applications for data collection and analysis developed at global level for country-level and local contexts. Use base minimum requirements and iterative development with climate resilient FFP standards and design – not 'science fits all'. Design for replicability and scale.
2. Develop new tools and NSDI that links surveying and climate related variables impacting land, water and marine environments to support sustainable resource management and climate resilience. Operationalise this data and analysis into national environmental policies.
3. Design 3 Dimension/4 Dimension (3D/4D) geodata, digital twins, Building Information Modelling (BIM) and scenario simulation for risk analysis and to support green development, such as for cities and communities. Implement digital twins to simulate drought, flood, and hurricane/cyclone scenarios, supported by satellite and Internet of Things (IoT) data. Use digital twins for ground water assessment, waste management and measuring urban heat island (UHI) effect.
4. Use geospatial technologies, tools and innovation, such as Unmanned Aerial Vehicle (UAV) photogrammetry, Light Detection and Ranging (LiDAR), Interferometric Synthetic-Aperture Radar (InSAR), Geographic Information Systems (GIS), for real-time data capture and dissemination of information to decision-makers to develop strategies for climate resilience, including sustainable natural resource management.

5. Use the IoT to create interconnected systems to facilitate continuous data capture and assessment. Increase the use of uncrewed systems, such as UAVs, Unmanned Surface Vehicles (USVs), Autonomous Underwater Vehicles (AUVs) for rapid and agile data acquisition. Re-design these systems for online-based surveying, in-person surveying and mobile mapping.

6. Support climate scenario development with harmonised software, data formats and interfaces, to include what exists, land rights, environmental hotspots (for example areas of biodiversity, degradation/restoration) and land use overlays, land use planning and strategic visualization.

7. Learn from how digital twin approaches have been adapted to accommodate surveying (accurate real world) and BIM (planned world) and what building blocks are needed to create this approach for climate, which may need a long-term view.

8. Use platforms like Copernicus, which provides free satellite information for global monitoring, Google Earth Engine which enables large cloud-based geospatial analysis and USGS's Earth Explorer platform for global datasets on climate, disaster response, land use/land cover. Platforms like these reduce the digital divide and democratize access to environmental and disaster risk data.

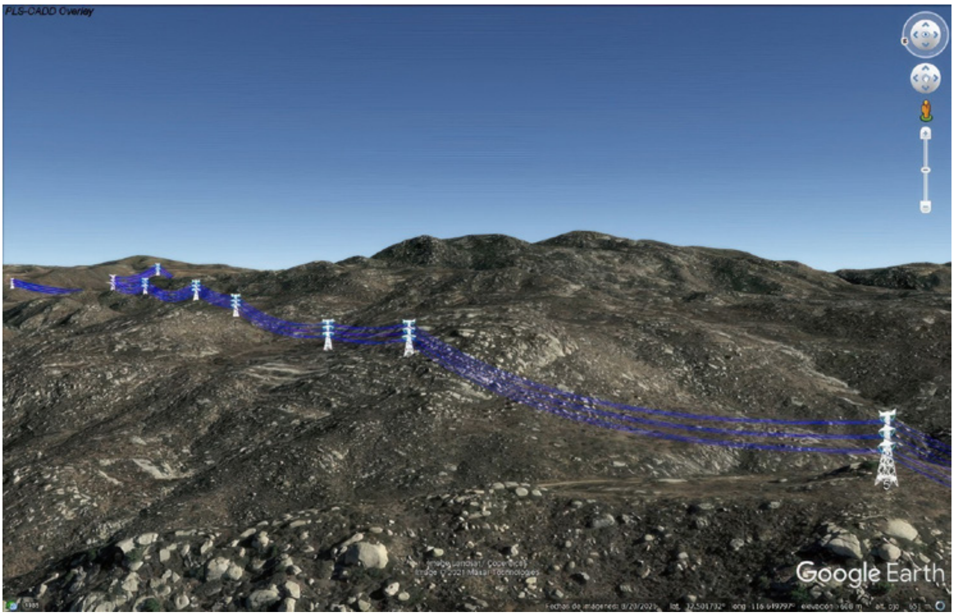


Photo 5: *Digital twin used for the design and layout of a transmission line, using geospatial models to simulate the real environment and optimize infrastructure planning, 2024. Photograph courtesy of Federal Electricity Commission of Mexico.*

9. Enhance metadata creation and collection/classification and build capacity to use metadata even if it is spatially or contextually limited, together with quality assessment.

10. Enable real-time BIM data accessibility for accurate building layout and as-built verification, thereby underpinning design and planning implementation for climate resilience.

11. Bring together data creating unified smart digital reality of buildings to identify conditions and understand what maintenance is needed during a building's lifetime to maximize its lifespan. Document entire buildings before embarking on repairs, reconstructions or renovations.

12. Develop cost effective local data collection and analysis applications to determine land cover/land use baselines, critical infrastructure, socio-economic vulnerabilities, including elevation models and historical datasets.

2.3.2 Artificial Intelligence (AI), machine learning and foundational models

1. Use AI, big data analytics, neural networks and machine learning powered systems to support decision-making based on spatial data analysis, while ensuring human level oversight is retained.

2. Open new pathways for data driven geospatial decision-making by using the Large Language Models (LLMs) being proposed to streamline and make more efficient GIS analysis.

3. Use AI in geospatial applications to enhance different types of decision-making (see examples below).

Examples of AI in geospatial applications: *1) for predictive analytics; 2) efficient workflows; 3) scale image recognition and visualisation; 4) scenario development; 5) trend and pattern recognition; 6) more easily provides meaningful insights; 7) more accurate prediction and automation; 8) to handle and clean vast geospatial datasets thereby increasing the scale of projects; 9) improvement of the quality of the work; 10) to move from specialized tools to general applications; 11) from sensors to solutions.*

4. Increase access to archived and non-public geospatial data (for example non-geo-referenced aerial images) for rapid and agile climate action, noting that AI geospatial analysis is limited by data scarcity.

5. Support decision-making by using machine learning in geospatial applications (see examples below).

Examples of machine learning in geospatial applications for decision-making: *1) for more rapid climate action; 2) neural network and machine learning improves land use change detection and accelerates cadastral updates, providing invaluable inputs for disaster risk reduction; 3) changed design and rendering of the world in countless ways; 4) automated detail design; 5) accelerated design processes; 6) use of organizational knowledge; 7) combining multiple parts of work processes; 8) reduction of errors; 9) connecting digital and physical worlds; 10)creation and use of classification taxonomies; 11) workflow design; 12) information/feature extraction and classification.*

6. Use AI and applications of augmented reality (AR), virtual reality (VR) applications and extended reality (XR) linked to the improvement of communication and information system software, to fast-track climate action.

7. Integrate pre-trained models and AI Application Programming Interfaces (API) (Google Vision, Hugging Face, OpenAI) in the classification of satellite images and climate data.

8. Use deep neural networks and transformers for early detection of vegetation/land cover changes, water bodies, and urban sprawl.

9. Use AI trained foundational models that enable cross-sensor modelling (see examples below).

10. Utilise foundational models that are being developed to monitor global land use change that need to be integrated with local land use data to improve climate-related land management.

Examples of use of AI trained foundation models: *1) for more accessible high-quality geospatial image classification; 2) video analysis; 3) depth estimation; 4) measuring the distance between two objects in an image; 5) querying images; 6) cleaning up images. Use AI, machine learning and visualisation approaches to overcome one of the greatest challenges for land-related climate action, namely large-scale (non-forest) data analysis of land use change and other changes.*

11. Only in emergencies must AI as a "black box" be trusted to do the rapid processing needed to address the problem (Nepal). Integrate geospatial technologies with machine learning for enhanced disaster management.

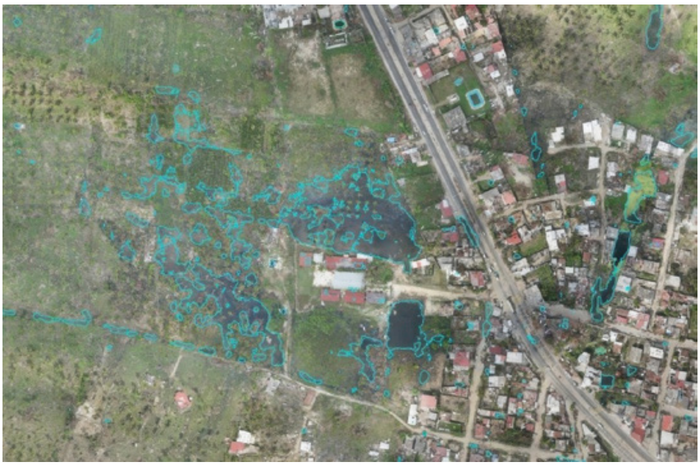


Photo 6: *Automated identification of water bodies and areas with water presence using AI applied to planning reconstruction strategies after Hurricane Otis, Mexico, 2024. Photograph courtesy of Federal Electricity Commission of Mexico.*

2.3.3 Challenges

1. Caution must be used with generative AI and LLMs. Data accuracy and reliability must be ensured with cautious data management. Governments are being cautious about generative AI and LLMs in the geospatial domain regarding the use of AI, sharing data with AI and relying on AI.

2. While commercial Earth Observation (EO) data sources are very good, they are not focused on low-cost, high revisit and/or coverage constellations which much of the anticipated market expansion will look to utilize. Only very recently has EO data become more readily available. The market for EO has huge potential for Environmental Social and Governance (ESG) and carbon trading frameworks, but the details have still to be worked out.

3. The digital divide between the global north and south.

4. Some geographic areas and spatial data topics are better covered by spatial data than others, such as for example countries from the global north.
5. Climate related spatial data using satellite imagery is common, but it is often not sufficiently accurate, or at the right resolution or detail for national and local planning and implementation. It is challenging to find the additional spatial data methods needed to make it useful at the right resolution and detail.
6. There are insufficient or incomplete spatial data base sources that are accurate and transparent for climate action. Those datasets that do exist are often not publicly available.
7. Shortage of useful publicly available climate and spatial information models that can be used to predict climate change, forecast and build scenarios using spatial and historical data to support policy makers. Use of climate models requires high levels of knowledge, high specification computers, extensive computing power, data base and internet access, all of which is not always available in the global south.
8. Data, methods and models are often not accurate, robust, tested or quality assured. There is little focus on comparing and contrasting emerging new methods and models, technology and satellite and aerial imagery to quality assure their accuracy and correctness.
9. There is an inability to design base minimum system requirements which facilitates iterative development.
10. Land Information Systems (LIS) are land focussed rather than also including the climate related variables that impact land tenure, land use, and development.

2.4 CLIMATE ACTION 4: INCREASE TECHNICAL CAPACITY, INCLUDING AI USE

New and complex climate challenges can be addressed, in part, because of new technology. Increasing technical capacity for climate resilience also involves a strategic, responsible, and regulated adoption of AI and advanced digital technologies within surveying and geospatial workflows (South Africa). The use of AI in geospatial applications offers significant opportunities to improve analytical capacity, response speed, and informed decision-making. However, AI should be understood as a decision-support tool, designed to augment the analytical capacity of professionals, and not as a substitute for expert judgment or the fundamental principles of surveying. In this context, its implementation should align with FIG's FFP approach, ensuring that the level of accuracy, technological complexity, and operational effort is proportionate to the risk, scale, and impact of each climate application. Clear principles should be adopted that guarantee reliable and ethical results, especially when applied in contexts that affect people, territories, and critical infrastructure. AI use should always be in accordance with national rules.

2.4.1 Tools and methods

1. Design harmonised digital reference frameworks for surveying and climate.
2. Re-design reference frames and geodetic systems (particularly the International Terrestrial Reference System (ITRS) and Frame (ITRF)) to account for changes

in earth systems due to climate change including: tectonic plate motions; land deformation and subsidence; glacial isostatic adjustment; polar ice melt; monitoring Earth's gravity change over time (Satellite Laser Ranging (SLR)).

3. Use AI with explicit human oversight mechanisms (human-in-the-loop and human-on-the-loop) in critical contexts related to climate resilience, such as for land administration, cadastre, land-use planning, strategic infrastructure, disaster risk management and the protection of territorial rights. These human oversight mechanisms ensure that the results generated by automated models are reviewed, validated and, where necessary, corrected by professionals trained in surveying, geomatics, and geospatial sciences, preserving professional accountability and the technical traceability of decisions.

4. Ensure that the AI model's level of complexity, the required spatial accuracy, and the temporal resolution is proportional to the risk, scale, and impact of the climate application. AI should be designed to respond to real and contextual needs, avoiding oversized or inappropriate solutions that compromise the system's sustainability or hinder its implementation at the local level.

5. Undertake systematic quality assessment processes of AI models applied to spatial data, including, at a minimum, verification of spatial accuracy, identification of geographic and temporal biases, representativeness of training data, and explainability of the results. Base AI models on geospatial data whose quality has been assessed in terms of accuracy, completeness, consistency, and currency. Identify and manage spatial and temporal biases arising from uneven data distributions, as well as to clearly document the limitations of the generated results, in accordance with the principles of quality assessment and testing of new tools.

6. Use internationally recognized regulatory and technical frameworks to do this, such as the ISO 19100 series standards (data quality, metadata, and interoperability) and the Open Geospatial Consortium (OGC) specifications (Australia), which facilitate the exchange, harmonization, and reliable reuse of geospatial information.

7. Develop data using standards that machines can be trusted to interpret.

8. Undertake explicit local recalibration and validation processes for models trained with global or generic data to ensure their suitability for specific national, regional, and community contexts, particularly in regions of the global south where environmental, social, and territorial conditions exhibit high variability. The absence of these processes can lead to inaccurate or biased results that compromise public decision-making and institutional trust.

9. Ensure that AI is built to incorporate training data from data scarce areas so that bias is reduced in output.

10. Strengthen the algorithmic governance of geospatial AI, guaranteeing complete data traceability, model auditability, and transparency in the analysis processes. "Black box" approaches should be avoided when AI results inform public policies, infrastructure investments, decisions that affect vulnerable communities, territorial rights, land use planning or critical infrastructure. Models and methodologies aligned with the principles of Responsible Artificial

Intelligence (RAI) should be prioritized. These models and methodologies allow for the interpretation, justification, and clear communication of results to decision-makers and local stakeholders.

2.4.2 Institutions and capacity

1. Integrate the implementation of geospatial AI into institutional governance frameworks that address the management of technical, ethical, and social risks. This includes assessing potential impacts on equity, privacy, security, and environmental sustainability, modelling (see examples below), as well as for alignment with national policies, regulatory frameworks, and recommendations from international organizations.
2. Establish clear responsibilities for institutions that adopt AI for climate resilience for the use, maintenance, and updating of models, as well as accountability mechanisms for errors, unintended impacts, or incorrect decisions based on automated results. This principle is key to strengthening public trust and institutional legitimacy.
3. Increase knowledge, capacity, tools and methodologies across all spatial data capture and analysis options to produce reliable geospatially based analytical statements for decision-makers, particularly national and local government and local communities.
4. Increase capacity to create interoperability for:
    i. NSDI;
    ii. data acquisition;
    iii. making data-sets interoperable, sharing and analysis across satellite imagery;
    iv. photogrammetry;
    v. surveys of surveying data and climate data;
    vi. the use of cloud based geospatial solutions linked to communications.
5. Build capacity to use scaled spatial data for climate modelling at regional or national scales (see examples below).

Examples of climate modelling: *1) forecasting of events; 2) scenario development; 3) planning and implementation for managing vulnerable groups including SIDS; 4) managing vulnerable terrain; 5) national and transnational biodiversity hot spots; 6) balancing environmental goals, food security, economic growth/poverty reduction and land and water governance. Learn to use different data collection methods as a wide range of spatial data is needed for modelling including: 1) metadata; 2) historical; 3) current; 4) 3D/4D, often in real time (for disaster for example); 5) appropriate accuracy; 6) high resolution for detail; 7) land and property rights; 8) different climate contexts; 9) IPLC people and territories; 10) local data; 11) crowdsourced data; 12) citizen data.*

6. Address the digital divide and where possible leapfrog with new technology, such as using satellite imagery from various EO missions to map areas that have not been mapped, or have not been recently mapped, or need to be mapped at large scale.

7. Affordability and technical costs for innovation often underpins the digital divide so consider base approaches with iterative steps.
8. Re-design for freely accessible/public data, open source, offline and weaker computing power and technical and financial capacity options. Facilitate users' needs and adaptations by building low-cost, high revisit and/or coverage platforms. Address the technological challenge around consistent data communication in remote areas.
9. Use intuitive interfaces that automatically reduce the learning curve and reduce the likelihood of errors, with seamless data transfers between devices and platforms which enhances a collaborative work environment.
10. Increase the technical options to clean up spatial data from multiple sources, including quality assessment, at the level of accuracy and detail appropriate for the task.

2.4.3 Challenges

1. Surveyors need to increase their capacity at scale to be able to develop software and associated tools that enable reliable geodata analysis critical for monitoring, mitigating and adapting to climate change. They need to be able to effectively extract and convert data from multiple sources into useful qualitative and quantitative information that can inform decision-makers and guide them towards implementing solutions. To do this more investment is needed in geospatial infrastructure for climate resilience.
2. The digital divide between the global north and south can be a key constraint, this is particularly true for AI computing power.
3. There is a lack of capacity in assessing different surveying methodologies in terms of the rapidly evolving technology, against cost, efficiency, time and carbon footprint.
4. Technological advances have made it easier for people without a surveying background to complete many geospatial data collection tasks. However, they lack the knowledge to represent the data correctly in reference frames and miss the technical field procedures for checking reliability and best data quality. Surveyors need to fill this gap by increasing their ability to become data managers.
5. There is insufficient capacity to develop spatial data and portals for climate change adaptation and mitigation that are useful for local government and local communities in terms of detail and replicability.

2.5 CLIMATE ACTION 5: QUALITY ASSESSMENT

Surveyors produce reliable, authoritative data based on robust science and should work with other experts to build robust scientific evidence for climate action. Together they should assess the quality of the co-created geospatial data and the technologies used to create it.

2.5.1 Tools and methods

1. Quality assess, from a surveying point of view, the internal capabilities of institutions to address the climate crisis in national contexts with respect to the FFP technology trends that support climate resilience.

2. Ensure continuous quality assessment for climate resilience by introducing the accreditation/licensing of surveyors undertaking surveying tasks for climate resilience at the national, regional and local levels.

3. Increase capacity to assess various sources of technical innovation and available datasets with respect to resolution, coverage, classification systems and record length.

4. Assess system sustainability over the full data lifecycle from gathering and maintaining data (for example an NSDI), to analysis, retrieval of results, and continuous monitoring of progress through key performance indicators (KPIs) (South Africa). This role is critical for tracking the success of adaptation measures.

5. Assess geospatial applications and data intended to adapt and mitigate climate change, including the surveying methodology used and land, water and climate data analysis for different surveying and climate target audiences and contexts. There are a range of data sources for climate purposes, many of which are freely available such as data from: earth observation; UAV photogrammetry; ground observation; open street map; and Copernicus and Google Earth Engine platforms. Quality assess the outputs from this data from a surveying context and for those customers who want to comply with surveying standards.

6. Compare emerging methodologies and climate models, satellite imagery and (historical) datasets as time series. Confirm data accuracy, integrity of the data repository, data continuity and clean up and categorize the data, including public or private metadata.

7. Assess the different technical methods and processes in terms of the rapidly evolving technologies, against cost, efficiency, time, and carbon footprint of each product and service.

8. Adapt and quality assure accuracies for rapid action and scale using satellites for small-scale, UAVs for mid-scale, and terrestrial surveys for high-accuracy and urban centres.

9. Assess AI products for integrity, data management and manage the risk associated with AI and its bias. Risk categories include:

    i. impaired fairness;
    ii. regulatory infringement;
    iii. privacy concerns;
    iv. malicious use;
    v. security threats;
    vi. interpretability and reliability;
    vii. impact on the environment, society and governance;
    viii. third-party risks;
    ix. customer misunderstandings.

10. Ensure the production, use, re-use, and disposal of surveying equipment and associated tools fits within a sustainable lifecycle.

2.5.2 Challenges

1. Surveyors have generally not worked closely with environmental experts in data collection and analysis. Surveyors need to build capacity and scale up their ability to work with other experts and manage other experts to assess the quality of co-created geospatial data.
2. AI quality assessment capacity for customers and users is weak.
3. There is a large gap in the accreditation/licensing of surveyors undertaking surveying tasks for climate resilience at the national, regional and local levels.
4. There is a lack of capacity for identifying and assessing sources of technical innovation and available datasets with respect to resolution, coverage, classification systems and record length.
5. Work has started but needs to be scaled with respect to the re-use, and disposal of surveying equipment and associated tools within a sustainable lifecycle.

2.6 CLIMATE ACTION 6: GOVERNMENT-LED RESPONSE TO CLIMATE ISSUES, INCLUDING LOCAL GOVERNMENT

Government-led (including local government) climate action is critical to reach national environmental goals, which are rapidly evolving. Collaboration and coordination across all of government have become key to the delivery of national environmental goals and plans. National Land/Land Administration Departments have a vital, often under-represented, role to play in supporting the delivery of climate resilience.

2.6.1 Coordination across government

1. Support national government decision-making in a range of sectors with geospatial data and analysis. National governments are breaking down their carbon emissions goals by sector and then working out how to adapt and mitigate the climate impacts. The sectors include agriculture, environment, urban, transport, energy, mining, water, forests, waste management, manufacturing, construction, and marine and more. Each sector requires context specific geospatial data and analysis and land administration support.
2. Determine what land-related government departments need to do to deliver on the national environmental goals and their capacity gaps. Identify the lead government agency for each climate aspect (for example Agriculture, Energy, Transport, Water etc). Support networking and collaboration between them to achieve common objectives in achieving national environmental plans, such as the Nationally Determined Contribution (NDC) on carbon emission reduction.
3. Strengthen access to funding for surveying for climate resilience by engaging with Environmental Departments and committees and supporting national environmental policies (see examples below). These internationally accepted country reports linked to the COPs (Committee of Parties) are informed by the interlinked challenges of climate change (carbon), biodiversity loss, land degradation/desertification and sustainable development.

Examples of key international environmental plans: *1) Nationally Determined Contribution (NDC) commitments of countries on carbon emissions; 2) National Biodiversity Strate-*

gic Action Plan (NBSAP) on biodiversity protection; 3) Land Degradation Neutrality (LDN) on land degradation/desertification and restoration; 4) National Action Plan (NAP) identifying actions for key national actions.

4. Work with the Environment Department to develop country pledges (NDCs etc) for these key international environmental plans that are more credible strategies for climate resilience and ecological sustainability. Ensure that these country reports address the impact of climate, biodiversity loss, degradation on the land rights of vulnerable people through strengthened territorial justice and resilience.

5. Support coordination and partnering across government departments and within public-private-academic partnerships to increase climate action delivery. Support government-led multi-stakeholder approaches to upscale surveying for climate resilience, including through capacity building and technology transfer.

6. Develop government policy-data feedback loops so that policy guides data initiatives, while data initiatives also inform policy development. Use this to facilitate adjustments to strategy and tactics.

7. Help to develop land policies, laws, regulations, institutional frameworks, applications, procedures and disclosure standards that support climate resilience and address a range of land related climate and disaster issues.

8. Support the development of a coherent sustainability framework in the built environment industry. Develop robust building codes that support the adoption of passive building designs and innovative technologies and align regulations with national carbon emissions goals.

9. Help to create robust land and land use policies and legal provisions that addresses landless and homeless people displaced by climate induced natural disasters. Policies need to also cover conflict related to displacement and migration, including in natural resource areas.

10. Support government to resolve regulatory conflicts around environment and spatial issues.

11. Support cross border cooperation between national governments to manage natural resources (Arctic region, discussed for The Gambia), such as mountains and rivers, and competition over natural resources, such as water access.

12. Develop data to support different government departments to target owners/rights holders for specific climate related communications (see examples below).

Examples of climate related communications for: *1) the reduction of vulnerability to risks; 2) finding owners of polluting parcels; 3)identifying areas eligible for subsidies; 4) identifying occupants requiring relocation during managed retreat such as for example for sea level rise; 5) identifying resource permit holders rather than just owners; 6) identifying rights, restrictions and responsibilities.*

2.6.2 Areas of focus

1. Invest in strengthening technical capacity, not only in digital tools and computing power, but also in the development of professional skills, regulatory frameworks, and institutional capacities, that enable surveyors to evolve from data collectors to managers, evaluators, and guarantors of reliable geospatial information.

2. Support government to build capacity to undertake data collection and analysis and scenario development for decision-makers, such as through using climate models and simulation.

3. Use data and scenario development to balance the land, water and natural resources demands of growing populations and rapid urbanization with environmental goals, economic growth/poverty alleviation, and land governance. Build capacity to identify priority options, potential compromises, different scenarios for decision-makers etc. (see Figure 2. above).

4. Support government-led development of a climate strategy and road map with key strategic outputs that support the adaptation of the land administration and land tenure systems to be climate resilient. Support government to monitor the KPIs of each of their NDC targets, across sectors and in the respective plans.

5. Support the creation of regional and urban land management recovery and resilience plans for natural and climate induced disaster.

6. Re-design the Land/Land Administration and/or Environment Department's role to include support for both the monitoring of conflict over land and natural resources and to simultaneously support government inspection/enforcement teams on the ground, particularly in areas of deforestation.

7. Create user friendly standardised geo-data services, portals and interfaces for local government and people on the ground to support climate impact.

8. Manage public/state land and other public assets to mitigate the effects of climate change. Major areas of focus should be the periphery of cities as urban sprawl impacts climate sensitive areas, natural areas and agriculture/food security. Coastal cities sprawl will be impacted because of forecast sea level rise. Protect biodiversity and manage land degradation in rural areas or green spaces within or adjacent to urban areas.

Photo 7: *Drought impact on grasslands and wildlife.*
Photograph courtesy of Paul Augustinus, 1985.

9. Support local governments to be future ready through technology transfer and capacity building.

10. Increase public awareness of the evolving climate resilience legal framework that impacts their property, land, water, livelihoods, infrastructure, and of high-risk areas where vulnerable communities are settled.

11. Develop cross border coordination mechanisms with neighbouring countries to jointly manage shared ecosystems. Develop joint border spatial plans, particularly for river basins and shared forests. Conduct joint environmental and social assessments for cross boundary projects such as roads and energy corridors (discussed for The Gambia).

2.6.3 Challenges

1. Coordination across governments, involving Lands Departments with the multi-agency environmental side of government, is weak. This means that financial capacity and the ability to access green funding is a key constraint for Land Departments. Lands/Land Administration Ministries need to be embedded in national multi-agency environment committees.

2. Many countries' climate reports (NDCs) to the United Nations do not consider the land requirements needed for proposed mitigation actions. Major land gaps have been reported. The land sector needs to provide support to government so that they can assess the land requirements needed for climate mitigation, including comprehensive reporting in their NDCs. This would provide a stronger basis for measuring global carbon goals and their achievement.

3. Many governments do not have a coherent strategic framework, priorities, road map, KPIs that support the adaptation of the land administration and land tenure systems to be climate resilient.

4. There is limited capacity for Lands Departments to form partnership arrangements with public-private-academic stakeholders to increase climate action delivery.

5. A coherent sustainability framework for the built environment industry is often missing, including robust building codes.

6. Governments are often unable to address issues because of regulatory conflicts around environment and spatial issues.

7. There are gaps in land policy and legal provisions to address landless and homeless people displaced by climate induced natural disaster.

8. Cross border cooperation to manage natural resources is often missing.

2.7 CLIMATE ACTION 7: CUSTOMERS AND USERS OF SURVEYING FOR CLIMATE RESILIENCE

Customers, users and governments need to be supported with geospatial data as they respond to climate resilience market trends, regulatory requirements and disclosure standards. They need to be helped to better understand and use geospatial data for these purposes. New climate regulatory demands are regularly emerging for businesses, customers and users. Data needs, and the way to meet these needs, is continually evolving. Good customer service by knowledgeable surveyors is key for climate resilience for people and the environment.

2.7.1 Tools and methods

1. Strengthen customer relations around new climate-related geospatial technology capabilities and market segment to improve customer satisfaction. Re-think how to market surveyors' knowledge, skills and approaches to be more useful to customers and users for climate resilience as new markets open-up.
2. Surveyors should find innovative ways to ensure their clients understand the value of their services in the climate resilience area of work.
3. Surveyors should provide services that add climate resilience value for their clients, so they stand out in a crowd.
4. Use different methods to appeal to a range of customers and users by undertaking cost, time and quality assessments of the different types of technology.

Photo 8: *Conducting photogrammetric drone flights to generate orthophotos, digital twins, and cartographic products, aimed at emergency response following Hurricane Otis, 2024.*
Photograph courtesy of Federal Electricity Commission of Mexico.

5. Support customers to develop sustainable business models (see examples below).

Examples of business strategies for climate resilience: *1) integration of climate resilience into the business strategy; 2) setting targets/goals; 3) creating purpose/values; 4) creating products/services; 5) showing evidence of impacts/action; 6) commitment; 7) leadership; 8) innovation; 9) communication; 10) transparency; 11) supply chain management and monitoring; 12) insurability; 13) reporting to government to fulfil regulatory requirements.*

6. Engage actively in public discourse and policy advocacy. Be part of the cultural shift to ensure that policy is implemented through actionable steps. This should also serve to attract new customers, users and new business strategies.
7. Support customers, including donors, who need assessed and measured climate change impacts, linked to the environment and food, within a context of constantly evolving legal disclosure standards (see examples below).

Examples of measurement types: *1) measuring land use change; 2) land degradation desertification and drought; 3) biodiversity loss; 4) sea level rise; 5) flooding; 6) subsidence; 7) carbon estimation; 8) forests/ deforestation/ reforestation; 9) fires; 10) land-slides; 11) earthquakes; 12) supply chains; 13) green and blue infrastructure; 14) heat islands; 15) utilities management 16) impact of mining; 17) spatio-temporal changes in land cover/land use change.*

2.7.2 Challenges

1. Surveying and climate resilience is a rapidly evolving field and customers and users cannot easily engage with it without the knowledgeable support of surveyors. The ability to make this link for them so they can build new business models needs more focus in the industry.
2. There is a gap in surveying and data delivery regarding the ability to engage with new climate regulatory demands and disclosure standards.
3. There is increasing competition between geospatial data for climate resilience provided by surveyors and that provided by other data scientists, with insufficient understanding of the value addition of surveyors.
4. Surveyors often avoid participating in public awareness raising, a key issue in this field.

2.8 CLIMATE ACTION 8. EDUCATION, TRAINING AND CONTINUING PROFESSIONAL DEVELOPMENT

Surveying for climate resilience presents new challenges and opportunities for surveyors. New knowledge and skills, built on existing knowledge and skills, will be required. While some of this can be acquired on the job, it will also involve dedicated education, training and continuing professional development (CPD) courses.

2.8.1 Tools and methods

1. Use and adapt international guidelines, principles, methods and tools such as the:
   i. UN-GGIM Task Team work on Geospatial Information for Climate Resilience;
   ii. UN Economic Commission for Africa, African Land Policy Centre, Guidelines for the Development of Curricula on Land Governance in Africa;
   iii. Arab Land Initiative of UN-Habitat/Global Land Tool Network work on Strengthening Academic Foundations;
   iv. UN FAO and UNCCD Technical Guide on the Integration of land tenure and combating desertification (see Useful References).
2. Undertake a government-led capacity assessment of the country and identify gaps, opportunities and strengths for climate action by surveyors that need to be filled by education and training on climate resilience.
3. Gear education, training and continual professional education towards scaling up the work force to support climate resilience (see Climate Action 9 below).

4. Government should work with, and support training institutions to scale up the workforce.
5. Embed surveying for climate resilience in surveying training programmes as core curriculum, including as a new model for Teaching Essentials for Responsible Land Administration (TERLA).
6. Create short courses for upskilling those already in the sector (CPD). Design modular university courses in AI and Geomatics for climate resilience, with levels ranging from fundamentals to advanced applications.
7. Partner with governments and NGOs to develop laboratories within existing institutions working on geospatial resilience.

Photo 9: *Young professionals and delegates at 5th FIG Young Surveyors Network Asia and Pacific Meeting at the Land Management Training Centre, Dhulikhel, Nepal, under the Ministry of Land Reform and Management, Government of Nepal.*
Photograph courtesy of Government of Nepal.

8. Build capacity for climate action within Land/Land Administration Departments by upskilling and embracing new technology to deliver climate goals.
9. Study the first principles that lie behind spatial data acquisition, systems and software programmes, to more rapidly adapt workflows and technology for climate action and innovation.
10. Learn how to:
    i. assess the ecosystem of climate data available, quality assess its usefulness for integration with the datasets traditionally produced by surveyors, including for land administration;
    ii. create cost effective use cases for scaling up action using new technology applications with interoperability to support evolving climate impacts;
    iii. measure and verify using climate data and analysis linked to land administration data and systems and strengthen interoperability between different datasets;
    iv. deploy, replicate and scale new climate actions, using surveying and geospatial data and analysis, into government, non-government, customers, society;

v. create future scenarios and assess potential trade-offs and compromises between climate goals, economic and good governance goals;

vi. identify climate finance opportunities and write proposals to get it.

11. Strengthen a range of soft skills (see examples below).

Examples of soft skills: *1) cross discipline and communication skills; 2) leadership, management and working with new stakeholders; 3) flexibility and adaptability to new opportunities; 4) customer relations; 5) ethics and the responsible management of technology including AI for inclusive development and climate action; 6) how to respond to global dynamics (social, economic, environmental); 7) balancing FFP and standards through quality assessments; 8) land governance issues in a competitive natural resource setting; 9) negotiate precision, timeliness, cost, relevance and modern technology with ethical concerns; 10) mediation, dispute resolution and conflict management; 11) how to better support clients introduce climate resilience in their business models; 12) knowledge of the climate vocabulary; 13) knowledge of the environmental goals' countries are trying to reach; 14) what climate products are emerging that impact surveying and geospatial business (for example NDCs, EEZ, carbon offsets).*

2.8.2 Challenges

1. While there is a huge increase in knowledge in surveying and climate resilience, as evidenced by the number of climate related abstracts submitted for FIG annual/ quadrennial conferences, this knowledge has not led to the creation of education and training and short courses and professional development at scale.

2. The surveying industry has not yet identified the shortage of capacity building options as a key issue.

3. Country-level capacity assessments of what is needed for education, training, short courses, professional development have not yet started, often a key first step to addressing a capacity gap.

4. Training institutions will need to be re-geared. While some institutions have already engaged on this work (Nepal), most institutions need to start the journey.

2.9 CLIMATE ACTION 9: SCALING UP THE WORKFORCE

The climate crisis is rapidly unfolding. Surveyors play vital and varied roles in supporting climate resilience, from disaster recovery to green-blue infrastructure, to safeguarding the land rights of vulnerable people and more. The work force needs to be scaled up to play these roles.

2.9.1 Tools and methods

1. Determine the work force needed to respond at the scale necessary, including through the introduction of new technology. Government should lead national assessments regarding the delivery of the national environmental plans and develop a strategy to scale the work force. Local governments should do the same for their jurisdictions. Upskilling should be an integral component of this upscaling.

2. Increase public-private-academic partnerships to build capacity, including encouraging small firms to take a greater role.

3. Increase the number of qualified (licensed) surveyors and technicians. Attract people into the industry who come from non-traditional backgrounds, such as data and computer science, engineering or other Science, Technology, Engineering, Mathematics (STEM) backgrounds, who are making the connection between their skills and the importance of geospatial data and climate resilience.
4. Become data managers who coordinate data capture, use of the most appropriate equipment by non-surveyors and assess data quality.
5. Support and employ women surveyors and help them to reach their full potential.
6. Support young surveyors, who are often more familiar with new technology and have a greater interest in addressing the climate crisis, to take leadership roles.
7. Develop a national framework for incorporating para-surveyors to help bridge gaps in the availability of licensed surveyors, in countries with a shortage of licensed surveyors. This could also facilitate rapid mapping and data collection during climate-related disaster response.
8. Work with, and strengthen, the role of local authorities.
9. Increase scale and efficiency through workflow process and project management software, automated processes, new cost and time effective management technology. Adopt user-friendly workflow services that enable faster data transfer between the field and the office.
10. Use AI responsibly to increase scale and efficiency.

2.9.2 Challenges

1. There is a shortage of people with the skills, knowledge and capacity to undertake surveying work. Immediate efforts are needed to scale up the workforce to support climate resilience and emerging work as the crisis unfolds. The surveying industry at global and national levels need to address this gap to ensure national and international environmental goals can be met.
2. The surveying industry has not yet identified the shortage of the work force for climate resilience as a key issue.
3. There is little experience of how to scale up the industry and professional work force to deliver climate actions at the scale necessary. Immediate efforts are needed to scale up the workforce, focused on the surveyor’s role as data manager, young surveyors and to encourage women into the profession.

3 FOCUS AREAS FOR SURVEYING FOR CLIMATE RESILIENCE

The six main focus areas for surveying for climate resilience are:

- Climate Action 10: Rapid, agile, climate resilient fit-for-purpose land administration;
- Climate Action 11: Strengthening marine data systems;
- Climate Action 12: Re-designing urban and peri-urban systems for climate resilience;
- Climate Action 13: Sustainable rural land management;
- Climate Action 14: Disaster risk management;
- Climate Action 15: Climate, conflict and land.

3.1 CLIMATE ACTION 10: RAPID, AGILE, CLIMATE RESILIENT FIT-FOR-PURPOSE LAND ADMINISTRATION

Land administration systems underpin the real estate and wealth of the world (see Figure 3. below). The climate crisis could be an important trigger that leads to changes in land administration systems, facilitating the development of new and innovative FFP systems that support climate resilience. While many land administration systems have yet to embrace climate resilience, some countries are adopting new approaches (Brazil, Pakistan, Nepal, Scotland).

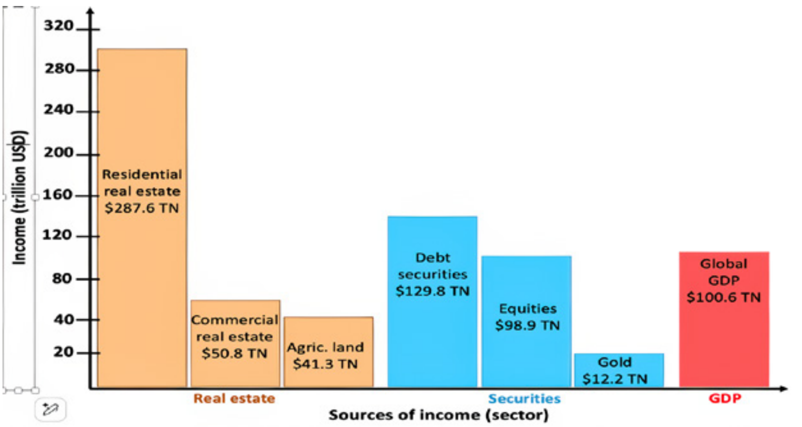


Figure 3: *Size of global real estate in comparison to other sources of wealth in 2022 (2023). Sources: Savills Research, and Savills Research using World Bank, Bank for International Settlements, World Federation of Exchanges, World Gold Council. Graphic adapted by and courtesy of U.E.Chigbu, 2025.*

3.1.1 Re-design FFP land administration systems for climate resilience

1. Re-design FFP land administration systems to make them more rapid and agile for a range of climate related purposes (see examples below).

Examples of FFPLA re-design for climate resilience: *1) to give smallholder farmers, IPLC land rights also so that they will look after their land; 2) access to land for displaced people/resettlement; 3) expropriation and compensation; 4) access to new land for relocation* *and rebuilding with security of tenure and infrastructure; 5) pre-emption rights; 6) climate strategic land use planning; 7) risk management; 8) mass valuation, including for adverse impact on value or increase in value; 9) damages and disturbance for climate projects; 10) land banking; 11) land consolidation; 12) land readjustment; 13) property taxation; 14) land and property valuation; 15) valuation of ecosystems, environmental services, and climate risks.*

2. Use FFP land administration (FFPLA) to increase the security of tenure of people (SDGs 1,5), for land restoration (SDGs 1,5,15), carbon management (SDGs 7 and 13) and protecting biodiversity (SDGs 14 and 15).

3. Use existing international frameworks such as the Framework for Effective Land Administration (FELA), as part of the United Nations Integrated Geospatial Information Framework (UN-IGIF).

4. Re-design all components of a land administration system, namely land tenure, land value, land use and land development systems to be climate resilient.

5. Develop rapid and agile climate resilient FFP land administration systems with flexible and affordable standards for different climate and geographic contexts and audiences. Design base minimum system requirements followed by iterative development and address the digital divide.

6. Identify, map and re-design FFP land administration to include important climate locations such as wetlands (Uganda), peatland (Scotland), rivers, lakes, streams, aquifers, and integrate them into national spatial plans and local development schemes. Include cross-boundary shared ecosystems such as wetlands and rivers. Demarcate and enforce riparian buffer zones and floodplain reserves (discussed for The Gambia). Integrate groundwater protection into national and local land use plans. Strengthen national water governance, administration, management and data for climate resilience.

7. Develop interoperability between forest cadastres and land cadastres as they often overlap, while re-designing a climate resilient FFP land administration system.

8. Re-design land administration systems to support the development of blue-green projects, such as World Bank funded infrastructure projects, within legal frameworks to ensure sustainability and resilience.

9. Identify adequately priced land for: solar farms, hydroelectricity, transmission lines, landscape and watershed management, flood management and public transport.

10. Support access to land, land assembly and dispute resolution at scale, through robust land administration systems, to support the delivery of infrastructure, networks, corridors and affordable housing. Often project land is already occupied by informal settlements, with little information available about the people who own the land, tenants, renters and temporary residents. People with temporary residents' rights are the most vulnerable to infrastructure development and create challenges for land acquisition for infrastructure.

11. Work within legal frameworks by using new regulations to adapt to the climate crisis. Respond to evolving climate-related legislation, regulations and disclosure standards that impact property and land rights.

12. Land and nature are better protected where there are tenure security and formalised rights, including formalised group and private rights. Introduce multiple tenure systems for localised climate action, to support legal pluralism, community tenure, continuum of land rights options, decentralised land administration and community-based GIS systems.

13. Support local climate action through user friendly approaches and portals for IPLC people and local governments.

3.1.2 Re-design FFP land administration data for climate action

1. Re-design land administration systems data. The land parcel can form the basis for flood preparedness, vulnerability mapping, risk assessments, climate adaptation, data driven relief efforts, fair compensation to local communities, emergency preparedness (Punjab, Pakistan) and enforcement of forest boundaries.

2. Re-design the current processes of NSDI, land information system (LIS) and land information management (LIM) systems to make them more useful to support coordination across government, including by linking the land administration and land use planning systems.

3. Re-design the current processes of NSDI/LIS/LIM by identifying the data and workflow important for climate and disaster decision-making.

4. Create up-to-date land registry data for climate action, including of public/state land and building rights and other public assets. Develop transparent records and registers of land and property ownership and land rights, including property and land and natural resources purchase prices, to achieve equity in climate protection-related advantages and disadvantages.

5. Create a unified digital system for urban and rural areas for all government departments (including local government), covering owners, tenants and informal occupants.

6. Develop cadastral/land tenure maps/data ecosystems so that they include the identification of rights, duties, responsibilities and restrictions about the environment.

7. Increase capacity to identify, assess, clean, classify and link climate/carbon and biodiversity and land degradation/restoration data, with land administration data to produce analytical statements for decision-makers.

8. Clean data such as: DTMs, subdivisions and land plot design, registers of owners and tenants, associated local land rights, public land and roads. Increase technical capacity using robust methods of workflow analysis, classification, accuracy, fine-tuning datasets, cataloguing, visualisation and analysis for the integration of different formats. Data quality often varies regionally and can be used in local contexts with pragmatic approaches (for example wetland contexts in Uganda).
9. Continue the work on digitisation of the cadastre and land registries, including by addressing data quality, cybersecurity and openness.

3.1.3 Re-design tools and methodologies

1. Innovate and re-design current land administration methodologies and re-prioritise the focus of work. Re-design involves the use of new and evolving technology for increased efficiency and addressing additional complexity and climate uncertainty regarding:
   i. cadastral and topographic data;
   ii. geospatial data infrastructure;
   iii. land value (assessment of land value, collection of property tax);
   iv. land use (policies and spatial planning, land use control);
   v. sustainable development (economic, social and environmental).
2. Ensure that new land systems and projects, whether they are climate projects or land projects or both together, are capable of being sustained.
3. Use new technology and insights to develop scalable solutions, new infrastructure, interoperability, that suits technical and human capacity, time available and budgets. Introduce the use of AI and remote sensing applications.
4. Develop new FFP business models use cases and show cases, involving all stakeholders.
5. Re-design reference frames and geodetic systems to ensure land administration systems are climate resilient using evolving technology.
6. Develop multi-purpose positioning infrastructure for sustainable land administration systems and for development, also within the context of the digital divide.
7. Re-design the Land Administration Domain Model (LADM), and the Social Tenure Domain Model (STDM) that can be used by communities, to support climate resilience.
8. Create one stop shops for digital geospatial land administration data that is interoperable with climate data.

3.1.4 Land use planning

1. Re-design land use planning for adaptation and mitigation to avoid climate problems and to build climate resilience. It should:
   i. balance governments' economic, environmental and societal goals when managing land use change. This should be done with reference to the context of local emergent priorities particularly in emergencies;
   ii. make good use of public land and derelict building spaces;

iii. protect agricultural areas from encroachment by urban areas;
iv. facilitate risk identification and management and use hazard maps, inventories of land occupation of informal residents, and maps of potential relocation areas after disaster;
v. be used for land use control, particularly of hazard-prone land, and the prevention of inappropriate land use;
vi. support resettlement and relocation of displaced people (for example SIDS and sea level rise) where appropriate;
vii. control building standards that are enforced;
viii. implement land use controls to prevent illegal land use change.

3.1.5 Valuation for climate resilience

1. Strengthen state-wide valuation systems by the adoption of appropriate international valuation standards (IVS) and professional practice capacity and capabilities.
2. Support government and the private sector to re-design the valuation system to also include natural capital for consideration when expropriating land and paying compensation for registered and unregistered land. Develop clear and transparent methodologies for compensation and insurance for climate related damage to properties.
3. Re-design systems and update legislation to allow for banded or mass valuation initiatives, including using technology for the assessment of climate impact.
4. Strive to ensure that valuation systems' policies and laws take into account non-market values, such as social, cultural, religious, spiritual and environmental values where applicable.

3.1.6 Challenges

1. Many land administration and geospatial systems have not yet been re-designed for climate resilience putting people, economies and the environment at risk.
2. Most land administration systems have rigid laws and institutions which have not been adapted to climate resilience. The bundle of rights associated with registered land rights needs to also accommodate climate (carbon) mitigation and adaptation, biodiversity and land degradation issues. Some of the issues such an FFP land administration should be able to accommodate include for example, land reclamation, dredging, uncontrolled construction/ development, pollution, unregulated use, unclear zoning, informal occupation (discussed for The Gambia) and soil sealing.
3. There is a lack of understanding of how-to re-design FFLA systems for adaptation and mitigation and to work out best options for climate justice.
4. In many countries the majority of people's land rights have yet to be documented. Yet without security of tenure it is unlikely that people will look after the land and its natural resources in a sustainable way. Land administration systems need to be scaled up to meet this challenge.
5. Most climate projects are being undertaken without reference to the land administration system, which is likely to impact sustainability. Climate projects

need to be linked to the land administration system, such as the large scale internationally funded climate REDD+ projects.

6. Current processes are not FFP in relation to expropriation, compensation for land use and adverse impact on value, damages and disturbance, making it difficult for comprehensive land use planning and the valuation of risk.

3.2 CLIMATE ACTION 11: STRENGTHEN MARINE DATA SYSTEMS

Geospatial data systems are needed to protect and manage the marine environment, for example mapping plastic pollution, and for strengthening marine cadastres and hydrospatial administration models. Robust geodetic and hydrographic surveying infrastructure, Digital Elevation Models (DEMs), tide gauges and benchmark networks, in terms of the national vertical datum, are key to the protection and management of the marine environment.

The more robust these systems are the more resilience there is in the system and the better the response to the climate event. Accurate and reliable geospatial data is needed to support decision-makers as they establish and regulate the multiple overlapping rights associated with the marine and coastal domain, and to protect vulnerable coastal communities and infrastructure.

3.2.1 Tools and methods

1. Develop new tools and an NSDI that creates a seamless land and marine cadastre and links surveying and climate related marine data.
2. Ensure that technical innovation does not increase risks to people and vulnerable populations using the marine environment.
3. Map coastlines with topographic and bathymetric LiDAR technology, particularly areas that are highly populated, have significant coastal infrastructure, and where there is a higher risk of coastal inundation and erosion. Use the data to create detailed DEMs (3D maps) of the coast and adjacent seafloor. This provides a baseline for future measurement of change because of climate events and natural hazards, builds use cases, and supports the updating of nautical charts for maritime safety. This will help decision-makers keep communities and infrastructure safe and protect ocean biodiversity through improved habitat mapping (New Zealand).
4. Re-design ITRF, ITRS and geodetic systems to account for changes in gravity and glacier melt.
5. Plan for the use of large marine areas in Exclusive Economic Zones (EEZs), particularly in SIDS, where tenure and use rights need to be planned for multiple occupancies.
6. Address the digital divide and build the capacity of surveyors to capture data on the large expanses of marine environment that SIDS must manage to address the impacts of climate change (The Caribbean and Pacific Islands).
7. Design geospatial applications to manage the digital divide, that takes cost and capacity into account. This is especially important for measurements of climate

impacts in SIDS and low-lying countries, which are disproportionately affected by sea level rise, storm surges, tsunamis.

8. Recent satellite data from the Surface Water and Ocean Topography (SWOT) system provides high resolution observations of sea level changes enabling a more accurate assessment of sea level changes. SWOT enables the high resolution (within 1 km from land) monitoring of coastal regions, including coastal currents, storm surges, and regional sea level change. It allows for detailed mapping of coastal areas and understanding flood impacts. SWOT provides resolution from kilometres to 10–25 metres and detailed observations of sea level change in harbours, coastal areas as well as larger inland water bodies.
9. Satellite altimetry is a technique that measures the height of the ocean surface by transmitting a radar signal from a satellite to the sea surface and recording the time it takes for the signal to return. For more than three decades missions such as TOPEX/Poseidon, Jason, and Sentinel have provided precise, global, long-term observations of sea surface heights using satellite altimetry. These measurements give comprehensive and accurate evidence of climate change and sea level rise.
10. GNSS interferometric reflectometry (GNSS-IR) uses multipath noise to estimate the height of coherent surfaces below the antenna. It is used in remote locations (deployed remotely with a solar panel), where the installation of tidal gauges is not feasible, to measure sea level, sea state and other environmental parameters.
11. For hydrology monitoring, live sensor data can be integrated with traditional hydrology and hydraulic models ensuring the interoperability of spatial data services with platforms including ESRI ArcGIS Online, QGIS, Waze, Google and Mapbox.
12. Integrate big data analytics into existing geospatial frameworks to enhance marine related disaster resilience.

3.2.2 Challenges

1. Significant gaps remain in the development of a seamless land and marine cadastre, and re-designed reference frameworks to address emerging global climate conditions.
2. There is a significant digital divide in terms of costs and capacity.
3. There is a limited adoption of planned retreat/managed retreat (of people due to sea level rise) options, including difficulty in managing uncertainty in the climate models.
4. Data collection in the marine environments is still at an early stage. There is a paucity of marine data by comparison to land data.

3.3 CLIMATE ACTION 12: RE-DESIGNING URBAN SYSTEMS FOR CLIMATE RESILIENCE

Rapid urbanisation is occurring in many parts of the world. Although cities are relatively efficient carbon emitters because they are compact, they tend to sprawl into carbon sinks, such as wetlands, on their periphery because land on the periphery is cheaper. Already there is a shortage of affordable housing to buy and to rent in many cities and towns in the world. Property prices are increasing dramatically because of the shortage of residential units, and the climate crisis will increase this effect. The climate crisis will require new green-blue infrastructure and the redevelopment and rehabilitation of existing infrastructure after natural disaster events.

3.3.1 Tools and methods

1. Support local government collaboration and coordination, both vertically and horizontally, as well as with regional and national governments.
2. Develop policies and legal and institutional frameworks to support climate resilience in urban and peri-urban systems (China) at national, regional and local government levels.
3. Re-design urban systems at scale to support climate resilience for:
    i. people;
    ii. land and property and buildings;
    iii. the environment;
    iv. the economy/poverty reduction;
    v. scaling up formal housing delivery;
    vi. informal settlement regularisation;
    vii. peri-urban developments, including their transition into urban areas;
    viii. the delivery of green-blue infrastructure;
    ix. large scale climate induced migration and a high demand for urban land.

Photo 10: *Digital twin showing the entire layout of the transmission line, with an approximate length of 60km through the urban and peri-urban areas, facilitating comprehensive project planning and evaluation, 2024.*
Photograph courtesy of Federal Electricity Commission of Mexico.

4. Re-design geospatial and cadastral systems for climate resilience without undermining property rights (The Netherlands). In many countries surveyors are one of the key custodians of people's property rights.

5. Develop climate-related geospatial landscape metrices and analysis for decision-makers on cities, towns and their surrounding areas.

6. Strengthen urban LIS/NSDI systems integrated with climate data for land use planning. Strengthen LIS or inventories outside of the formal land administration system as many people do not have land rights documented within government systems.

7. Understand how to systematize strategic land use planning and add climate actions. Work out how to access land and corridors. Improve access to land for green-blue projects, including utilities and infrastructure, such as energy, infrastructure corridors, waste management, water (Namibia), roads and flood barriers.

8. Identify public land, (which often has temporary residents), areas for rehabilitation, old urban areas and infrastructure corridors, such as electric grids. Use land use planning for displacement prevention and resettlement management to ensure future urban growth does not negatively impact the environment (discussed for The Gambia).

9. Land use planning needs to be linked to the analysis of carbon emissions impact and focus on land intensification rather than only land costs (discussed for China). Climate sensitive areas need to be identified during planning.

10. Create smart cities through:
    i. cost effective applications;
    ii. smart city planning;
    iii. smart contracts;
    iv. green construction technology, designs and materials;
    v. the promotion of environmentally responsible projects;
    vi. resilience to flooding through flood monitoring and blue infrastructure (sea level barriers and structures, breakwaters);
    vii. resilience to fires;
    viii. smart transportation networks and safety measures governed by automation;
    ix. land management strategies that support climate resilience.

11. Design 3D, simulation, or digital twins for urban planning and green-blue projects. Use repeatable and rapid reality capture, expandable and open data modelling, and accurate and reliable data linked to new and evolving technology. Scale up the use of large-scale digital twins for climate action and scenario development for decision-makers in urban and peri-urban areas.

3.3.2 Green buildings

1. Balance carbon reduction, energy efficiency and costs, particularly when developing affordable housing.

2. Assess carbon emissions for the life-span of green buildings including upfront carbon when building (construction material, transport to site, construction and installation), building in-use (use, maintenance, repair, material replacement and refurbishment, energy consumption), and end of life (demolition) (discussed for South Africa).

3. Adopt optimal designs, simplified sustainability tools, use locally available and recycled materials and implement cost-effective energy-saving interventions, such as building orientation for optimal thermal energy.
4. Use appropriate software to model embodied and operational carbon emissions to control costs such as Revit, AutoCad, SketchUp outputting data into for example OneClick LCA.
5. Take into account the reduction of operational emissions through renewable energy technologies and insulation materials, contributing to the minimization of energy consumption throughout the building's lifespan.

3.3.3 Challenges

1. Many local governments are under-prepared, ill-equipped, lack financial and human capacity, and can be unwilling to invest in meeting the demands of urban expansion. The climate crisis will increase their burden.
2. Local governments often do not have the legal responsibility within government to address climate impacts. Climate functions and responsibilities is often unclear between national and local governments (Middle East). This is particularly true for land, a critical function needed to address climate impacts.
3. Many countries are not managing the urban sprawl impacting agricultural land, wetlands and forests.
4. Freeing up land and corridors for blue-green projects, including utilities and infrastructure, such as energy, infrastructure corridors, waste management, water, roads and flood barriers, is complex also because they often have temporary/informal occupants.
5. Many countries in the south have large scale informal settlements vulnerable to climate impacts. Often informal settlement regularisation is not keeping pace with their growth.
6. Green buildings often have high upfront costs associated with advanced technologies and construction methods. There are often knowledge gaps and inconsistent policies within the regulatory framework regarding green buildings. There is also a lack of financial options for small developers. Legislative support needs to be increased, as does industry collaboration. There is a need for awareness raising in the building sector.
7. Large-scale climate induced migration to urban areas will increase the demand for urban land, housing and services and augment urban sprawl. Urban areas are often not prepared for this large-scale climate migration, particularly regarding the lack of infrastructure to support urban growth.

3.4 CLIMATE ACTION 13: SUSTAINABLE RURAL LAND MANAGEMENT

Due to climate change and loss of biodiversity because of human activity, rural areas are becoming more prone to deforestation, desertification, degradation, droughts, floods etc. This threatens agricultural productivity, people's livelihoods, economic growth/ poverty reduction and the achievement of national and global environmental goals.

Neglecting rural sustainable land management undermines national food security, ecological conservation and neutrality goals. Climate smart agriculture and environmentally sustainable land use practices need to be promoted, and surveyors play a key role in this. Land use change is a major driver of climate change and is responsible for 13–21 percent of carbon emissions, mostly related to agriculture and pastoralists. The effects of climate change results in changes in livelihoods, human settlements, land use patterns, and tenure systems. Surveyors are involved in these land use change decisions, including access to, use of, and control over land and natural resources, and their implementation and enforcement. Surveyors have a key role therefore in undertaking actions quality assessed for their climate resilience regarding land use change.

3.4.1 Land use change and land use planning

1. Understand the environmental impacts of land use change decisions and move to climate actions that support adaptation and mitigation. Measure, monitor and track land use change to inform:

    i. land use planning;
    ii. land tenure security;
    iii. the valuation domain;
    iv. monitoring carbon emissions (discussed for Namibia);
    v. the identification of impacts of urban sprawl into agricultural and natural areas (China);
    vi. the identification of impacts of agricultural expansion into forests and natural areas (Brazil).

2. Re-design rural land use planning for adaptation and mitigation to avoid climate problems and to build climate resilience in rural areas (see examples below).

Examples of re-designed rural land management: *1) manage forests and re-forestation and avoid deforestation, particularly regarding the siting of roads; 2) land consolidation to improve agricultural productivity and increase the extent of natural areas (parts of Europe); 3) create biodiversity corridors; 4) support the restoration of degraded watersheds and rangeland; 5) support the decrease of livestock production (Ireland); 6) support the creation of carbon offsets; 7) use public land to build climate resilience; 8) ensure sustainable land management through appropriate land use allocation and control; 9) avoid hazard-prone areas; 10) improve water and flood management; 11) protect natural habitats from agricultural encroachment; 12) protect agricultural and natural areas from urban expansion.*

3. Support blue-green civil engineering projects through monitoring and infrastructure development of:

    i. wind turbines (on and offshore);
    ii. corridors/connectivity for electricity grids and water management;
    iii. flood management and structures;
    iv. deformation and analysis of engineering structures and environment.

4. Adopt and adapt new land management tools with scenario building features to support the design and evaluation of policy options for land use, land use change, particularly also in the forestry sector. Apply spatial filters to select appropriate areas to implement predefined mitigation measures and visualise their potential impact on the land use. Being able to review a range of scenarios for different locations makes it possible to assess the amount of carbon reduction potential, profitability, employment and habitat quality.

5. Create geospatial workflows for climate, land use planning and the communities (discussed for South Africa).

6. Use multiple tools and methods to create geospatial data on forests, invasive species in conservation areas, land use/land cover, watersheds (Nigeria), lakes and river quality (Ethiopia), wetlands (Nigeria), the impact of road construction (Nigeria) and mining on the environment (South Africa), and for biodiversity management (Botswana) and land use planning.

7. Where appropriate and ground truthed, use AI-driven insights for land management.

8. Enable stakeholders to explore land management alternatives across spatial scales and within different locations, also for land use planning in national and regional contexts.

9. Use citizen science data for monitoring (discussed for Uganda).

3.4.2 Land tenure

1. Re-design rural land administration systems to include the majority of the people, particularly in the global south, who often have no registered land rights. Land and forests are often better protected where there are tenure security and formalised rights, including formalised group and private rights. Limited systematic land tenure documentation in rural areas, particularly for local communities, hinders spatial analysis and climate action. The lack of land record documentation and data about IPLC peoples' property rights decreases the government's ability to support vulnerable populations, including during natural disaster.

2. Introduce multiple tenure systems for localised climate action such as group rights and the continuum of land rights (See Figure 4 below).

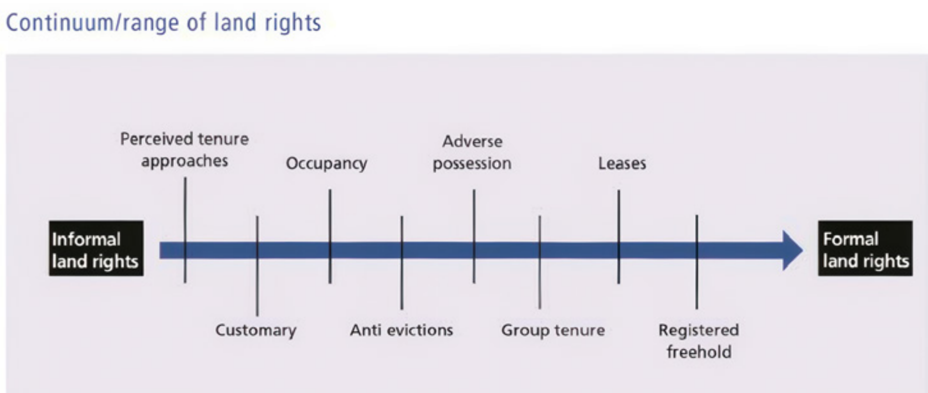


Figure 4: *The continuum of land rights. UN-Habitat/Global Land Tool Network, 2008.*

3. Ensure that the allocation of rights for specific parcels for large scale land-based investments (LSLBI) is climate resilient and does not cause disputes with local communities. Disputes can increase degradation as people stop looking after the land. Often large-scale investments, such as in cattle or intensive monoculture planting, can lead to deforestation.

4. Monitor and measure to support decision-makers to manage land and natural resources, where agricultural areas are illegally turned into urban areas and forests and natural resource areas into agricultural areas.
5. Monitor the introduction of climate resilient practices in agriculture (discussed in Nepal).
6. Ensure that the allocation of carbon offsets protects the land rights of local communities (under discussion in Kenya). Carbon offsets are often termed 'unbundled' property rights. When carbon offsets are being allocated ask 'what rights, whose rights, when were they acquired and what is the duration of the right, and what are the spatial dimensions (location, extent, boundary dimensions)'. Also check whether this information is in the public record and linked to the land administration system.

3.4.3 Forests and biodiversity

1. Increase geospatial work in forest areas as 50 percent of national environmental commitments (NDCs) on carbon (carbon sequestration/storage) are about forests, re-forestation, afforestation and the prevention of de-forestation. This is a large emerging market for surveyors. Millions of people live in forests often with no formal forest land rights. Forest edges are often un-surveyed/un-demarcated. Forest issues that need to be addressed include ownership rights (group and private), zoning (which often does not align with how people are using the land) and buffer zones. Many areas under the control of Forestry Departments have already lost their forest cover, or never had forest cover, or are agricultural areas, or even urban areas.
2. Overcome coordination issues across multiple government agencies involved in forest land and address legal challenges and create standard operating procedures. Civil Society Organizations are critical partners at local level for the social verification of land rights.
3. Zoning and land use management for forests and adjacent land needs to be in a unitary system to monitor forest encroachment. The forest cadastral data and land cadastral data should be interoperable and/or part of the overarching national cadastre.
4. Unregistered land rights within forests should be compensated when expropriated.
5. The alienation of forest land for IPLC people can be FFP both in terms of technical approach and administrative procedures. It does not have to be at the same due diligence level as the alienation of land for mining for example.
6. Assess the impact of mining on surrounding forests and vegetation and use the mining cadastre to protect the environment.

3.4.4 Challenges

1. National policies on climate, biodiversity, sustainable development and agriculture are not connected and are not informed by the work of surveyors, which means the land tenure and ground truthing lens is generally missing from the spatial data modelling climate forecasting. This seriously undermines implementation of environmental measures.

2. Surveyors generally work less in rural areas than in urban and peri-urban areas, yet their role is critical for food production and the protection of the environment.
3. The competition over land as a resource, including climate-impact-secure agricultural land (Nepal), increases the scarcity of land. This is also due to land grabbing by powerful actors and governments. All of this leads to the displacement of vulnerable populations.
4. Surveyors are often unaware that their work is closely linked to land use change, which is one of the greatest drivers of carbon emissions.

3.5 CLIMATE ACTION 14: DISASTER RISK MANAGEMENT

Surveying knowledge and measurement skills are needed for a range of different types of natural hazards and their intensity, which lead to disasters including hurricanes, cyclones, storms, storm surges, tsunamis, floods, fires, landslides, glacial bursts, earthquakes, extreme temperatures, droughts and more. Climate-related disasters displace millions of people around the world every year as their homes become uninhabitable, their livelihoods unsustainable and their lives at risk in hazard-prone areas (Nepal, Zimbabwe).

The land rights of vulnerable people need to be protected, and climate resilience promoted in the face of natural disaster. Geospatial and land administration systems need to be re-designed for the different natural disaster stages, to support specific local contexts, and to fit the different types of natural disasters. To address disasters, surveyors need to be involved in: identifying and assessing risks; developing knowledge, institutional capacity and political commitment for action; applying risk reduction measures; providing early warning; preparing for disaster and emergency management; undertaking post disaster recovery and reconstruction (see Figure 5. below).

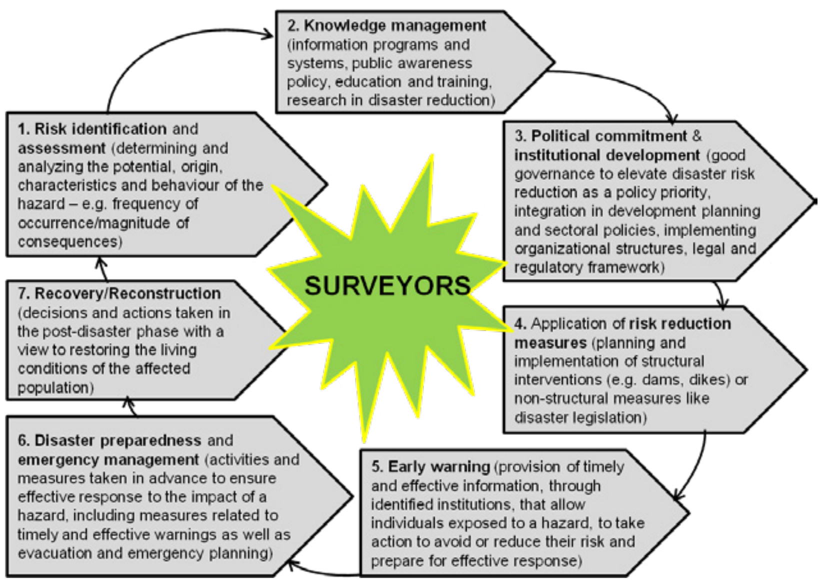


Figure 5: *The Surveyors' Role in Disaster Risk Management (FIG, Boateng, 2012).*

Disaster risk management is fast becoming a core role of surveyors. They undertake a range of fast-track responses for climate related natural disaster and displacement– globally, nationally, regionally and locally (see examples below).

Examples of surveying for fast track natural disaster and displacement management: *1) through geospatial data and early warning systems; 2) standby agreements and data sharing mechanisms for rapid and real time access to trusted data; 3) accessible and inter-operable digital land records and GIS data; 4) simulations; 5) drones; 6) GNSS; 7) aerial and earth observation data; 8) hazard and risk mapping; 9) post disaster needs assessments; 10) digital twins and AI to optimize emergency response (Mexico's electricity grid post hurricane); 11) surveying for climate adaptation and mitigation strategies, including developing resilient infrastructure.*

3.5.1 Policy, legal and institutional

1. Use and adapt international guidelines, principles, methods and tools, such as from the UN-GGIM Working Group on Geospatial Information for Disaster Risk Management.

2. Strengthen land administration and geospatial policy, legal, regulatory and institutional frameworks and strategies to address natural disaster (Indonesia) and recognize all forms of land tenure rights. Secure land rights are vital for recovery and reconstruction as they enable local communities to rebuild (lessons from Bangladesh, Nepal, India, The Philippines, Vietnam) including through:

   i. the harmonisation of disaster risk reduction policies with broader land policies, laws and regulations;
   ii. resilient, inclusive and adaptive land use policies that reduce disaster risk, enhance recovery, and safeguard the land rights of vulnerable people;
   iii. the updating of the laws and regulations to address emerging climate risks;
   iv. the prevention of natural disasters by implementing land-use policies that restrict development in high-risk areas, such as floodplains or coastal zones, to prevent the loss of life and property;
   v. building collaboration between government, local government, civil society and the private sector to coordinate land use decisions and disaster risk reduction strategies.

3. Secure standby agreements or framework licences with cross border national governments (China, European Union), regional governments or private geospatial data suppliers, to enable emergency response, risk and recovery from extreme weather events.

4. Facilitate cooperation between national mapping, cadastral and land registration authorities to overcome legal barriers to data access for disaster response.

3.5.2 People and communities

1. Support government-led approaches to prevent, respond to, and recover from, natural disaster in ways that embraces land governance to protect vulnerable people.

2. Include land tenure security as a core component for post disaster recovery. Ensure displaced communities can return to their land or receive adequate

compensation. Ensure rapid and clear identification of 'who' has 'what' rights 'where' to facilitate reconstruction and minimize disputes.

3. Survey loss and damage to displaced people, infrastructure destroyed, crops destroyed, land parcels destroyed, environment degraded, owners and tenants displaced, mortgaged land destroyed. Identify loss of value and investments in currently useful land, and land that was previously owned but can no longer be used (discussed in Nepal).
4. Address the issue of landowners and tenants and occupiers regarding valuation, compensation, reconstruction and relocation strategies.
5. Learning from international experiences, successful relocation is based on a clear legal foundation, standardised and equitable procedures, effective land tenure security, compensation measures, transparency, the simultaneous restoration of services and livelihoods, as well as anticipatory and stable financing. All of this is key for protection of the land rights of vulnerable people.
6. Work out what to do with the land use after disaster when undertaking strategic land use planning.

Photo 11: *Collapsed transmission tower after Hurricane Otis, Mexico, with surveying personnel conducting the corresponding technical assessment in the field, 2024. Photograph courtesy of Federal Electricity Commission of Mexico.*

7. Identify new areas for communities to re-settle with alternative livelihoods. Support vulnerable people's access to valuation (including natural accounting), compensation, access to new land and tenure security during climate-induced migration or relocation.
8. Evaluate and develop land management tools for climate induced displacement and migration strategies for climate change, and for climate projects that require the relocation of people, such as for forest conservation, solar farms, green/blue infrastructure etc.
9. Engage with communities when preparing for natural disaster. Merge land use planning, disaster risk assessment and management, and geospatial innovation to enhance tenure security and build community resilience.

10. Map vulnerabilities, infrastructure, critical assets and environmental hazards. Address the challenges of data gaps by working with local government.

11. Facilitate the use of participatory mapping to promote climate resilience, collect field data and for risk profile visualization and risk management. Assess needs and engage with stakeholders to accurately capture local vulnerabilities and housing structure limitations.

12. Empower communities through awareness raising about risk, early warning, insurance, access to investment and develop local adaptation plans of action. Emphasize the use of geospatial methodologies in building the capacity of local communities and build and maintain strong local partnerships to foster trust and sustainability in disaster risk management. Replicate and scale.

3.5.3 Land administration

1. Develop approaches to assess and address the impact of climate-change induced disaster on land administration systems. Land administration systems' data facilitates the management of people and land parcels during natural disaster and other climate related impacts (Bosnia-Herzegovina), such as for climate migrants to cities.

2. Develop land management and land administration systems that support climate resilience (Punjab, Pakistan) and build back better land tenure and land administration systems that have been destroyed or degraded by natural disaster, including effective government-led rehabilitation and relocation plans for government facilities.

3. Re-design and build geospatial and land administration systems that can prevent disasters or better manage risks, withstand risk, recover from disasters, in a manner that is transformative and progressive. Ensure that land administration systems are interoperable with hazard and vulnerability maps. Strengthen:

   i. digital land registries to keep track of land ownership and use to support efficient disaster recovery and reduce disputes;
   ii. land tenure systems by updating legal frameworks to recognize customary and informal land rights, especially in the post disaster recovery phase;
   iii. risk-informed land use planning including disaster resilient zoning, identifying areas of risk and safer zones for settlements, and natural buffers like wetlands and forests to reduce disaster;
   iv. building codes;
   v. the focus on disaster-resistant infrastructure;
   vi. valuation systems adapted for disaster.

4. Capture and securely store land administration and land tenure data in alternative off site systems to protect people's land rights, particularly when the land administration offices are exposed to disaster.

5. Use valuers early on in the emergency when compensation linked to pre-emergency property prices is made available for the reconstruction of residential properties.

3.5.4 Data, methods and tools

1. Use geospatial data to assess, model and manage acute and chronic risk to the environment (for example wildfires), economic risks (for example critical infrastructure) and risk to vulnerable communities (for example settlements in flood zones), using the appropriate risk assessment tools, data sources and modelling across multiple disaster scenarios linked to the needs of specific institutions or actors.
2. Develop innovative cost-effective applications from crisis to reconstruction.
3. Use big data analytics, machine learning and generative AI to predict and prevent natural disasters, with a focus on improving response and recovery efforts. Develop geospatial natural hazard and disaster standards to support all of government recovery after natural/climate related disasters. Inconsistent adoption of standards across government risks delays in disaster recovery workflows.
4. Integrate big data analytics into existing geospatial frameworks to enhance disaster resilience, forecasting, early warning, emergency, such as for bridges after flash floods.
5. Integrate accurate building data into flood risk models for better property valuation, disaster relief efforts and insurance pricing.
6. Assess flood risks for buildings using first floor elevation and precise location/placement data of the building to increase flood impact prediction and avoiding the blanket assumptions used by insurance and financial products.
7. Use terrestrial and airborne imagery, and where possible BIM-based visualisation, AI and machine learning. The machine learning may have to be adapted for local building contexts.
8. Use open-source foundation data standards for disaster to accelerate bureaucratic action and improve communication across government horizontally and vertically and drive innovation.
9. Undertake trend assessment on post disaster reconstruction.
10. Use new technology (for example InSAR) for disaster, subsidence or uplift for accurate annual mapping for specific locations to support natural disaster management.
11. Create innovative applications of cost-effective positioning to mitigate the impacts of natural disasters.
12. For natural disaster settings that require indoor positioning, combine Fifth Generation Mobile Network (5G) fingerprinting, augmented reality for component visualization, and sensor fusion (IOU, Wi-Fi, Wireless Local-Area Network (WLAN), Bluetooth low energy) for real-time guidance and accurate indoor positioning, when GNSS is unreliable indoors.
13. Integrate live continuously updating, geospatial data into platforms used by emergency managers for flood management. This creates a seamless operational system for disaster response, such as the one recently set up by the European Union for its 27 member countries.

14. Focus on interoperability with GIS platforms and transport data, enabling emergency managers to overlay flood forecasts with critical exposure data.

15. Avoid separate interfaces. Verify that the geospatial data correctly aligns with existing transport and engineering data and implement cross-validation procedures. Establish a unified data protocol.

16. Ensure that seamless integration does not lead to data latency during emergencies. Create real-time data visualization through web map services (WMS), web feature services (WFS) and ESRI REST services. During emergencies undertake manual cross checks with crowd-sourced inputs and after verification integrate the data with existing datasets (Nepal).

3.5.5 Challenges

1. Weak government-led responses after natural disasters, including that of, the Land/Land Administration Department, adversely affects vulnerable communities' efforts to rebuild their lives, impacting livelihoods and food security.

2. Reactive rather than proactive approaches are the most common approach to natural disasters. These reactive approaches focus on immediate humanitarian assistance, and neglect structured planning. Pre-established mechanisms are needed to map areas under threat from hazards, identify fallback sites, secure land tenure and involve communities in planning. Without this approach spontaneous displacements will just continue linked to the pressure of events.

3. Existing frameworks, whether regional instruments, such as the Kampala Convention (2009), or national disaster management legislation, tend to focus on sudden hazards (such as floods, storms, landslides). They neglect slow and irreversible processes (coastal erosion, desertification, sea-level rise) which require, not a rapid return to areas of origin, but a sustainable, secure and legally regulated solutions. Existing legal frameworks, by focusing on sudden-onset hazards, tend to channel resources toward emergency responses. This constrains authorities' ability to plan durable solutions for slow-onset processes.

4. Poor coordination between government ministries, local authorities, and technical partners such as UN agencies, international NGOs, or expert consultancies in risk management undermines efforts and leads to gaps in delivery. This can be worsened by an over-reliance on external funding, which is subject to aid cycles and changing donor priorities.

3.6 CLIMATE ACTION 15: CLIMATE, CONFLICT AND LAND

Climate, conflict and land are often inter-linked. Conflict can exacerbate climate issues, by leading to deforestation for example, and climate issues can trigger conflict, including violent protracted conflict. The drought and scarcity of water around Lake Chad and the rise of Boko Haram in West Africa is a good example of this. In these situations, people migrate, compete for land, water and natural resources and struggle for food security. Land administration lessons associated with emergency conflict settings need to be adapted for conflict-climate nexus settings and environmental goals included.

3.6.1 Policy, legal and institutional

1. Use and adapt international guidelines, principles, methods and tools such as from the UN Economic Commission, African Land Policy Centre guidelines on prevention and addressing land-based conflicts in Africa, and the Arab Land Initiative of UN-Habitat/Global Land Tool Network, including Housing and Property Restitution for Refugees and Displaced Persons, Implementing the Pinhero Principles in the Middle East and North Africa.

2. Rapidly create policies, regulations and operational procedures to address climate, land and conflict settings, including policies that cover conflict related to displacement and migration. This is especially important for urban areas where displaced people often congregate. Support local tenure systems in climate and conflict settings, for IPLC people, internally displaced people and refugees.

3. Strengthen professional ethics, standards and land governance approaches for emergency settings. All surveying in these settings should be to support vulnerable local communities.

4. Develop climate responsive land governance approaches and capacity to manage conflict over land and natural resources because of increased competition for resources and increasing land grabs and exploitation. Develop scenarios and options to manage conflict between landless and homeless climate displaced migrants degrading natural resources on public land in dispute with environmentalists.

5. Support climate related conflict resolution over land and natural resources by understanding all the viable options within the national and local legal and institutional frameworks for dispute resolution. This makes it possible to support a range of approaches such as:

    i. working with, and building the capacity of, local leaders to settle disputes (Somalia);
    ii. identifying public land and supporting administrative processes for (re)-settlement (Iraq);
    iii. tweaking regulations to facilitate dispute resolution without changing the law;
    iv. supporting participatory mapping for land use planning to address disputes (Darfur/Sudan);
    v. mapping to provide information to decision-makers involved in dispute resolution (International Organization for Migration (IOM) tracking movement of displaced people);
    vi. facilitating the resettlement of displaced people in such a way that their livelihoods are protected even as biodiversity hot spots are protected.

3.6.2 Land administration and people

1. Assess the impact of conflict and climate on the land administration system in the geographic locality of the conflict, including on the land administration offices. Work out what rapid agile climate resilient FFP land administration means for conflict-climate nexus settings. Design base minimum land administration system requirements followed by iterative development, addressing the digital divide. Build on the existing land administration system where possible and/or build a stand-alone system that can be later integrated into the statutory system (Iraq see below).

2. Re-design land administration systems, including NSDI and institutional processes, for peacebuilding, emergency access to land for displaced people, community empowerment (Darfur/Sudan), environmental hot spot protection, and food security. Safeguard women's, and especially widows, land rights in these contexts.

3. Capture and securely store land administration data in alternative off site systems to protect people's land rights, particularly when the land administration offices are captured by hostile forces and people are forcibly evicted from their homes. The valid data can facilitate post conflict resettlement and compensation (Iraq).

Photo 12: *Ms. Jeanine Hennis-Plasschaert, Special Representative of the United Nations Secretary-General for Iraq, handing Land Occupancy Certificates to residents from the Yazidi community. UN-Habitat. Photograph courtesy of UN-Habitat.*

4. Identify and predict natural and climate-induced risks related to conflict and support decision-makers with options.

5. Manage climate induced displacement of people, including migration, in emergency situations (see examples below) all of which have land administration challenges.

Examples of managing climate-conflict-related displacement: *1) by supplying housing, land and property, where possible using existing legal and institutional frameworks; 2) identifying public/state land rapidly for resettlement; 3) reducing planning standards and surveying requirements; 4) formalising customary land management arrangements; 5) protecting environmental hot spots, where possible; 6) using rapidly designed land portals to make returns and resettlement more efficient and able to work at scale. This helps displaced people to obtain up to date information on legal and administrative procedures and applications about the situation in their place of origin and new potential areas for settlement.*

6. Strengthen safeguards, like environmental impact assessments, for projects involving land acquisition or conversion or for land redistribution.

7. Collect and supply geospatial data for climate-conflict land and water nexus management and intelligence for safety and security. Strengthen data collection and disaggregation (e.g. gender, vulnerable groups), as well as timely dissemination.

8. Adapt and develop technology, spatial data and special tools, methods and processes for crises. Increase technical capacity to quality assess various sources of technical innovation and available datasets that could be used in an emergency conflict setting, particularly in data poor areas. Develop use cases and pilot them for scaling.

3.6.3 Challenges

1. Land administration lessons from emergency conflict settings have not yet been documented for learning so that they can be applied for climate resilience and conflict options (e.g. pastoralists and farmer management in northern South Sudan and their impact on forests; the impact of refugee camps on grassland recovery in Darfur/Sudan).

2. Conflict in areas and countries adjacent to conservation areas can lead to large-scale displacement and the need to replace livelihoods in new areas. It can easily lead to illegal, unplanned and large-scale land use changes. It. It can overturn conservation restoration measures and lead to land degradation, deforestation and biodiversity loss due to poaching.

3. Conflicts over the allocation of land and natural resources are often not successfully managed by the land administration systems and are particularly intense in urban areas.

4. Large scale land use change over time because of conflict, regarding grassland degradation and deforestation, is particularly hard to track because of inadequate geospatial data models and insufficient ground truthing.

5. There is a large knowledge gap with respect to the linking of environmental goals, conflict and land tenure/land administration within one framework at the large scale needed to understand and manage cross boundary land use change.

4 INTERNATIONAL ROLES

Climate Action 16: Role of international bodies linked to surveying is discussed below.

4.1 *CLIMATE ACTION 16. ROLE OF INTERNATIONAL BODIES LINKED TO SURVEYING*

International bodies linked to surveying have traditionally had a large influence on the re-design of geospatial and land administration systems. Their advice has been highly valued. Generally, the focus has been at the broad policy level (see Figures 6 and 7 below). However, surveyors are asking for practical examples of how to undertake climate resilient surveying, rather than policy directions. International bodies who want to engage in climate action and surveying should take cognizance of this as they work to support people and the planet.

4.1.1 Tools and methods

1. Encourage the use and adaptation of existing international guidelines, principles, tools and methods. Figure 6. gives a global example. Figure 7 below gives a regional example from Africa.

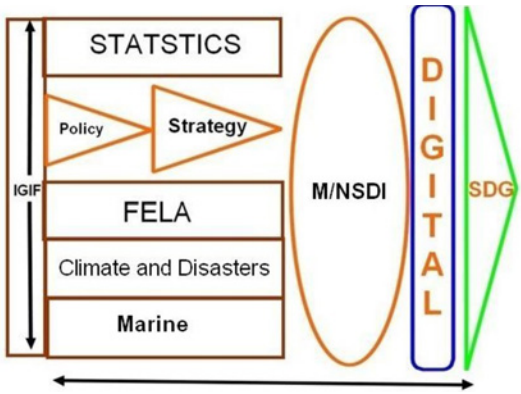


Figure 6*: Surveying link to international guidelines and goals.*
Graphic courtesy of M.Timoulali, Third Arab Land Conference, 2025.

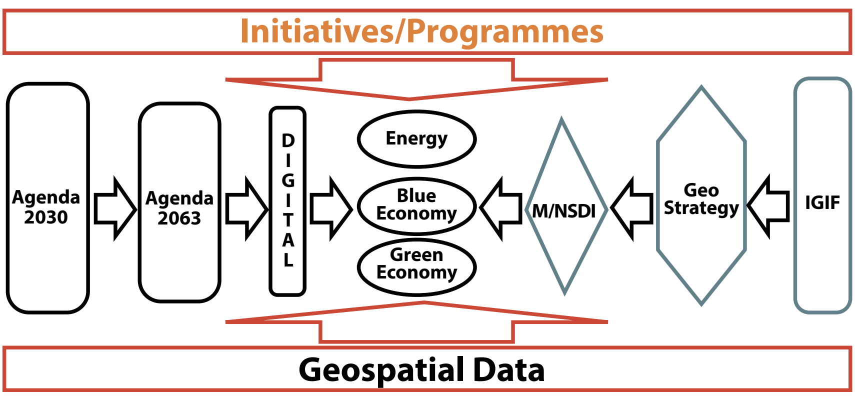


Figure 7: *Surveying link to African Union 2063 Agenda and the UN 2030 Agenda.*
Graphic courtesy of M. Timoulali, The Third Arab Land Conference, 2025.

2. Use existing land and marine international frameworks (see references) and their linkages to the SDGs (1, 2, 5, 10, 15, 16). For climate action, link these frameworks to the environmental goals on carbon emissions, biodiversity loss and land degradation/restoration issues.

3. Strengthen global and regional cooperation, partnerships and collaboration around the land and climate nexus for climate resilience and disaster risk reduction, including through technology transfer and stand by agreements for data supply during emergency, risk and recovery.

4. Link to major global climate-related organizations and funds. Be aware that their focus on land tends to be on land use rather than land tenure. Key organizations and funds include:

    i. UN Framework Convention on Climate Change (UNFCCC) (carbon) and its annual COPs;
    ii. UNFCCC Green Climate Fund;
    iii. UN Convention on Biological Diversity (UNCBD) (biodiversity) and its COPs;
    iv. UN Convention to Combat Desertification (UNCCD) (degradation/desertification) and its COPs;
    v. UN Environment Programme Green Climate Fund (GCF);
    vi. UN's REDD+ programmes working on greenhouse gas emissions and forests;
    vii. The World Bank's Carbon Partnership Facility.

5. Develop the products, services and data required to achieve the current SDG goals and the 2030 environmental goals; and in preparation for the next round of SDGs in 2030, which are likely to strengthen climate resilience.

6. Rapidly develop guidelines, manuals and operational procedures that can be quickly and easily adapted, domesticated, replicated and scaled up in countries, with the emphasis on operational procedures.

7. Develop new disclosure standards for national governments to adapt to local contexts to increase climate resilience of the national surveying systems. Re-focus on manuals rather than global policy alone.

8. Support policy formulation that facilitates scenario development for decision-makers that considers economic growth/poverty alleviation, environmental goals and vulnerable people.

9. Develop best practice manuals on the use of new technology and to meet the new and emerging climate crises, such as for natural disasters. Develop national and local use cases on what:

    i. is cheaper;
    ii. is cost effective;
    iii. has more functionality and climate impact;
    iv. suits the human capacity;
    v. suits the technical settings;
    vi. suits the institutional context (for example under-resourced government departments, small firms);
    vii. is scalable and replicable;
    viii. safeguards local communities, including women's land rights.

10. Develop and document best practices at national and local levels and create inventories of existing climate related surveying and geospatial solutions and use cases for replication and scaling to national and international levels.

11. Give voluntary capacity building and technology transfer that builds the capacity of national and local stakeholders.

12. Address the need for:

    i. high resolution public and free geospatial data for the better management of urban areas;
    ii. standby agreements between governments for natural disaster management;
    iii. the monitoring of land use change (LUC) with quality authoritative data;
    iv. linking technical designs to safeguarding vulnerable populations.

13. Give voluntary technical assistance and partner with organizations piloting novel scalable use cases for climate action at national and local levels. Design collaboration and partnership between organizations with geospatial skills and local communities.

14. Consider creating a geospatial monitoring body that oversees a global climate data governance pact with AI as a cross-cutting theme. Develop guidelines to prevent the manipulation of geospatial information through cartographic deepfakes.

15. FIG is a large international organization covering over 100 countries with a global presence. It is a member of the UN-GGIM Thematic Networks and its Functional Groups and sits on the board of the Global Land Tool Network of UN-Habitat. FIG also supports the 'Stand for Her Land' Campaign aimed at strengthening women's land rights across the 3 Rio Conventions.

16. FIG has made a good start on branding the surveying profession as having a critical climate action role to play. This is demonstrated by the increasing number of climate-related abstracts being submitted for FIG's annual Working Week and quadrennial Congresses. There were over 125 abstracts submitted to the 2025 Brisbane Working Week for example (see link for these in References). Strengthening this brand reaches humanities' environmental goals faster and at the scale required.

4.1.2 Challenges

1. There is a shortage of practical international policies, guidelines, manuals and best practice guidance linking land and climate with the latest technological advances that can be domesticated at national and local levels.

2. There is little in the way of use cases and inventories of what works well as existing climate related surveying solutions at the local level that can be scaled up to national and international levels.

3. There is no dedicated funding to document best practices and use cases or to develop an inventory. The role of surveying as critical to national and global environmental goals is generally not recognized by environmental audiences and funders.

4. There are weak linkages between current land governance approaches and environmental governance and goals at global and national levels.
5. There is insufficient capacity to transfer theoretical/international concepts and frameworks and adapt them to national and local contexts.

5 CONCLUSIONS

Surveyors undertake many critical climate actions, often involving multiple stakeholders. While governments play the leading role, the private sector, academia, national and international institutions, training institutions and those industries building new geospatial data, analytical methods and tools, are also key to surveying for climate resilience. Climate action involves technology, governance and people, which in the climate context also means safeguarding people's land rights and livelihoods and the environment.

To support the climate resilience of people and the environment, surveyors are strengthening and adapting professional standards. As new technology and processes emerge, quality assessment as well as testing and developing new data acquisition tools, are key. This is something for which surveyors are well known and it is vital for sustainability both in terms of system design and for climate resilience. This also means adopting and adapting AI and machine learning, guided by the reasoning of surveyors for accuracy. AI reinforces the surveyor's strategic role as a key player in the production of scientific, technical, and territorial evidence that supports informed, ethical, and defensible decisions for climate change adaptation and mitigation.

Most importantly, government-led programmes on climate resilience are critical for success. As governments try and meet national environmental, economic, social and governance goals simultaneously, surveyors can support decision-makers through the use of geospatial data to help build differing scenarios to enable decision-makers to make the best decisions. Customers, both existing and future ones, need to be supported, as they too walk the climate resilience journey of adaptation and mitigation. All of this opens up new markets for surveyors with their precision and authoritative data skills.

To ensure that the surveying industry can do the job, surveying education, training and continuing professional development needs to be re-geared along a spectrum from digital literacy to advanced analytics to support the development of surveying for climate resilience. This is also needed so that the work force can be upscaled and undertake the required climate actions locally, nationally and for the planet.

All of this work underpins the re-design of the land administration and geospatial data systems to support climate resilience. Rapid, agile, climate resilient FFP land administration is needed to support for example, natural hazard and disaster risk management and areas experiencing climate-related conflict impacting land. Urban and rural land administration and geospatial systems are being re-designed to prevent urban encroachment on adjacent agricultural and natural areas (China) and agricultural encroachment on natural areas and forests (Brazil).

Strategic land use planning and public land management that supports climate resilience is common but needs to be increased. A much greater focus is needed on forests than has been traditional among surveyors. Also, there needs to be more emphasis on creating smart green cities.

International and regional surveying bodies play a major role in supporting national organizations and can upscale this by providing manuals, documenting good practices for climate resilience and supplying use cases that can be adapted for local contexts.

The purpose of this FIG publication has been to identify some of the key surveying actions, methods and tools for climate resilience, for land, water and marine environments, for people, economic growth/poverty reduction and the planet. FIG presentations, papers and discussions at conferences and Climate Compass Task Force webinars were the main source of information for this publication, with academic literature and GIM articles used to identify some of the challenges. All of this informed the choice of the 16 Climate Actions. Prominent surveyors in the profession gave detailed comments on advanced drafts of this publication and supplied graphics, text and photographs. This strengthened the publication and confirmed the major climate resilience issues for surveyors.

This publication shows that surveyors are rapidly undertaking climate actions and adapting to the climate crisis but important challenges remain. There are numerous gaps in actions, tools and methods that need to be scaled, as only some countries have working solutions. Or the solutions are only being addressed in some countries in the global north. Or solutions are context specific and need to be documented and shared to other countries for domestication. Or they reflect goals still being discussed and worked on at country and local levels. The tools, methods and actions described here need to be scaled up dramatically within countries and across the world. There is an evolving need for even more innovative climate-related surveying approaches as new climate demands and trends emerge.

The COP30 organizers are encouraging everyone to design systems that respond to the climate challenges of 2030, 2035 and 2050. Using the COP30 organizers argument, adapted to surveying, the complexity of the climate issues, and the need to respond with both agility and rapidity, creates risks and opportunities for surveying-related climate action. Surveyors need to be prepared as legacy institutions are disrupted by the climate crisis. New models need to be developed to address new challenges where past assumptions become obsolete. New technology and inter-disciplinary research have already shown that climate-related complexity and different contexts support dynamism and adaptability.

Surveyors and surveying institutions need to look ahead to anticipate and implement geospatial solutions that are agile, iterative and adaptive to ensure sustainability of systems and the planet in the longer term. Systems need to be designed and re-designed to make them inter-generational and capable of constant evolution and experimentation. System-based climate resilience needs to be designed with exponential diffusion of solutions, while addressing bottlenecks and delays. A basket of tools needs to be used which integrates technology, governance and people. New technologies and applications need to be adopted and adapted that bridge gaps with speed, scale and resilience in ways that our current systems are still slow to incorporate and amplify. All of this will allow surveyors to make even greater contributions to climate resilience for people and the planet, with FIG as a key leader.

USEFUL REFERENCES

Ache, P., Wiejak-Roy, G., Kavanagh, J., Korinke, E.K. and Reydon, B. (2024) FIG Position Paper: Viewpoint on Transparency in Real Estate Markets In the context of rapid change and urgent challenges, a new definition is required.

African Land Policy Centre (2022) Guidelines on Prevention and Addressing Land-Based Conflicts in Africa https://repository.uneca.org/server/api/core/bitstreams/70602957-b81f-4891-8ec0-3807af1ef1c7/content

African Land Policy Centre (2022) Guidelines for the Development of Curricula on Land Governance in Africa: https://nelga.uneca.org/wp-content/uploads/2022/11/Guidelines-for-the-Development-of-Curricula-on-Land-Governance-in-Africa.pdf

Asian NGO Coalition for Agrarian Reform and Rural Development (ANGOC) (2024) Monitoring of land under conflict – incidence, drivers and impacts: A regional workshop summary report, 26–27 February 2024, Jakarta, Indonesia, ANGOC.

Boateng, I., Dalyot, S., Enemark, S., Friesecke, F., Hannah, J., Mitchell, D., van der Molen, P., Pearse, M., Sutherland, M. and M. Vranken (2014) The Surveyor's Role in Monitoring, Mitigating, and Adapting to Climate Change, FIG Publication No. 65.

Committee on World Food Security (2012) Voluntary Guidelines on the Responsible Governance of Land, Fisheries and Forests in the Context of National Food Security (VGGT).

Eklund, G.R., Childress, M. and G. Barnes (N.D.) A Global Land Alliance Policy Brief on Securing Indigenous Peoples and Local Communities' Land Rights in the Voluntary Carbon Market https://www.globallandalliance.org/articles/securing-indigenous-peoples-and-local-communities-land-rights-in-the-voluntary-carbon-market

Federal Electricity Commission (of Mexico) (2024) Otis, Chronicle of the hurricane that darkened Acapulco and the days to re-illuminate it. Corporate Engineering and Infrastructure Projects Directorate and Corporate Communications Coordination (in Spanish).

FIG Climate Compass Taks Force YouTube webinars/seminars presentations (2023–2024) https://www.youtube.com/@FIGClimateCompassTaskForce

FIG Working Week (2023) Orlando, United States of America, full technical programme and papers. https://fig.net/resources/proceedings/fig_proceedings/fig2023/techprog.htm

FIG Working Week (2024) Accra, Ghana, full technical programme and papers. https://www.fig.net/resources/proceedings/fig_proceedings/fig2024/techprog.htm

FIG Regional Conference (2024) Kathmandu, Nepal, on Climate Responsible Land Governance and Disaster Resilience: Safeguarding Land Rights. Full technical program and papers. https://www.fig.net/resources/proceedings/fig_proceedings/nepal/techprog.htm

FIG Working Week (2025) Brisbane, Australia, full technical programme and papers. https://www.fig.net/resources/proceedings/fig_proceedings/fig2025/techprog.htm

GIM magazine, multiple editions (2023–2025).

Hill, C. (2023) The good, the bad and the ugly of the surveying profession: Two decades of change. Article published in GIM magazine September, 2025. https://www.gim-international.com/content/article/the-good-the-bad-and-the-ugly-of-the-surveying-profession?utm_source=newsletter&utm_medium=email&utm_campaign=Newsletter+%7C+GIM+%7C+04-09-2025+&sid=175299

Khechen, M. (N.D.) Climate, land, and rights: The quest for social and environmental justice in the Arab Region: An Introduction. The Policy Initiative. https://arablandinitiative.gltn.net/library/publications/climate-land-and-rights-the-quest-for-social-and-environmental-justice-in-the-arab-region.

Namati (2024) How national legislation can advance carbon justice: A policy toolkit.

Shah, R.D. and B.W. Patna (2025) Climate Responsive Land Governance and Disaster Resilience: Safeguarding Land Rights in Asia. FIG Article of the Month for September, 2025.

Stand for her Land Campaign and Rio Conventions Advocacy Resources. https://stand4herland.org/rio-conventions-advocacy-resources/

United Nations Food and Agricultural Organization and United Nations Convention to Combat Desertification (2022) Technical guide on the Integration of the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security into the Implementation of the United Nations Convention to Combat Desertification and Land Degradation Neutrality. Rome and Bonn.

UN-GGIM-IGIF (N.D.) The Integrated Geospatial Information Framework and other UN-GGIM Frameworks and Publications. https://ggim.un.org/UN-GGIM-publications/

UN-GGIM (2025) Geospatial information for climate, environment and resilience, United Nations Economic and Social Council, Committee of Experts on Global Geospatial Information Management, New York, E/C.20/2025/11/Add.1. https://ggim.un.org/meetings/GGIM-committee/15th-Session/documents/E_C20_2025_11_Add_1.pdf

UN-GGIM Task Team on Geospatial Information for Climate Resilience (2025) Applying geospatial information to climate challenges. https://ggim.un.org/meetings/GGIM-committee/15th-Session/documents/Applying_geospatial_information_to_climate_challenges.pdf

UN-Habitat/Global Land Tool Network/Arab Land Initiative (2025) Strengthening academic foundations in land governance: online lectures. https://arablandinitiative.gltn.net/media/news/strengthening-academic-foundations-in-land-governance-online-lectures-hosted-in-collaboration-with

UN-Habitat, Government of Morocco (2025) Third Arab Land Conference, 18–20 February 2025, Rabat, Morocco. https://arablandinitiative.gltn.net/sites/default/files/2025-12/docs/report-third-arab-land-conference-with-recommendations.pdf

UN-Habitat, FAO, IOM, NRC, UNHCR (2025) Housing and Property Restitution for Refugees and Displaced Persons, Implementing the Pinhero Principles in the Middle East and North Africa. Advance Version. Beirut, Lebanon.

United Nations Office of the High Commissioner on Human Rights (2011) Guiding Principles on Business and Human Rights: Implementing the United Nations 'Protect, Respect and Remedy' Framework.

ABOUT AUTHORS

Dr Clarissa Augustinus

- Chair of the International Federation of Surveyors Climate Compass Task Force (2023–2026).
- Honorary Ambassador, International Federation of Surveyors (2014-).
- Co-coordinator and co-editor of United Nations Convention to Combat Desertification (2022) Global Land Outlook 2nd Edition on Land Restoration for Recovery and Resilience.
- UN-Habitat, Unit Leader, Land and Global Land Tool Network (GLTN), Urban Legislation, Land and Governance Branch (2003–2015) and Lead Founder of GLTN.
- Senior Lecturer in the Department of Land Surveying in the School of Engineering, Surveying and Construction at the University of KwaZulu Natal (1994–2000).

Professor U.E. Chigbu

Professor U.E. Chigbu is a professor in land administration and the Director of the Institute for Land, Livelihood and Housing at the Namibia University of Science and Technology. He teaches, researches, writes, advises, networks, podcasts and consults on methods for improving societal challenges through land governance.

Dr Charisse Griffith-Charles

Dr Griffith-Charles Cert. Ed. (UBC), MPhil. (UWI), PhD (UF), FRICS, MISTT holds a PhD in Geomatics from the University of Florida and retired in 2025 as Senior Lecturer in Cadastral Systems, and Land Administration, and Head of the Department of Geomatics Engineering and Land Management, in the Faculty of Engineering at the University of the West Indies, St. Augustine. She is a Registered and Licensed Cadastral Surveyor with the Land Survey Board of Trinidad and Tobago (LSBTT), Fellow of the Royal Institution of Chartered Surveyors (FRICS), President of the Commonwealth Association of Surveying and Land Economy (CASLE) and member of the Institute of Surveyors of Trinidad and Tobago (ISTT).

Dr M.D.E.K. Gunathilaka

Dr. M.D.E.K. Gunathilaka is a Senior Lecturer in the Faculty of Geomatics at Sabaragamuwa University of Sri Lanka. He holds MSc and PhD degrees in Hydrography from the University of Technology Malaysia and currently serves as the Coordinator of the BSc Specialisation in Hydrographic Surveying degree programme. His research expertise spans Hydrographic Surveying and Positioning and Navigation applications, with a strong emphasis on their application to coastal and marine environmental protection. Since 2016, he has worked closely with government agencies and private sector stakeholders in Sri Lanka to support evidence-based climate change mitigation and adaptation initiatives in the coastal and marine sectors. He serves as the Chair of Commission 4 (Hydrography) of the International Federation of Surveyors (FIG) for the 2023–2026 term and is a Member of the Royal Institution of Chartered Surveyors (MRICS).

Mr Lester Simon Ironside

Simon Ironside is a Licensed Cadastral Surveyor, and a Level 1 Certified Hydrographic Surveyor (AHSCP). He is a Senior Cadastral Surveyor at Toitū Te Whenua Land Information New Zealand, where he helps oversee the Cadastral Survey subsystem of the national Property Rights Regulatory System. His work supports confidence and clarity about the rights and responsibilities relating to land ownership. His extensive hydrographic experience was gained primarily from the industrial offshore sector, working on projects in the North Sea, Sicily, Nigeria, and New Zealand. He is active in Survey+Spatial New Zealand and FIG. He represents S+SNZ on FIG Commission 4, cochairs Working Group 4.3 Mapping the Plastic and is a founding member of the FIG Climate Compass Task Force.

Professor Rigoberto Alejandro Moreno Vázquez

Professor Vazquez is a specialist in surveying, geodesy, geomatics, and technological innovation, with over 23 years of experience in the energy, geospatial, and academic sectors. Since 2011, he has worked at the Mexican Federal Electricity Commission (CFE), where he serves as Head of the Innovation and Digital Solutions Department, promoting the integration of advanced technologies into the national electrical infrastructure. He holds a PhD in Development, with postdoctoral studies in Artificial Intelligence, and two master's degrees: one in Water and Energy Engineering, and another in Geomatics Engineering and Geoinformation. His undergraduate degree is in Surveying Engineering, and he is a professor and researcher at the University of Guadalajara. He has participated in strategic projects, emergency operations, and infrastructure reconstruction. He is a Senior Member of the IEEE, Secretary of UN-GGIM:ANA, and was recognized as a Geospatial World Rising Star in 2024.

FIG PUBLICATIONS

The FIG publications are divided into four categories. This should assist members and other users to identify the profile and purpose of the various publications.

FIG Policy Statements

FIG Policy Statements include political declarations and recommendations endorsed by the FIG General Assembly. They are prepared to explain FIG policies on important topics to politicians, government agencies and other decision makers, as well as surveyors and other professionals.

FIG Guides

FIG Guides are technical or managerial guidelines endorsed by the Council and recorded by the General Assembly. They are prepared to deal with topical professional issues and provide guidance for the surveying profession and relevant partners.

FIG Reports

FIG Reports are technical reports representing the outcomes from scientific meetings and Commission working groups. The reports are approved by the Council and include valuable information on specific topics of relevance to the profession, members and individual surveyors.

FIG Regulations

FIG Regulations include statutes, internal rules and work plans adopted by the FIG organisation.

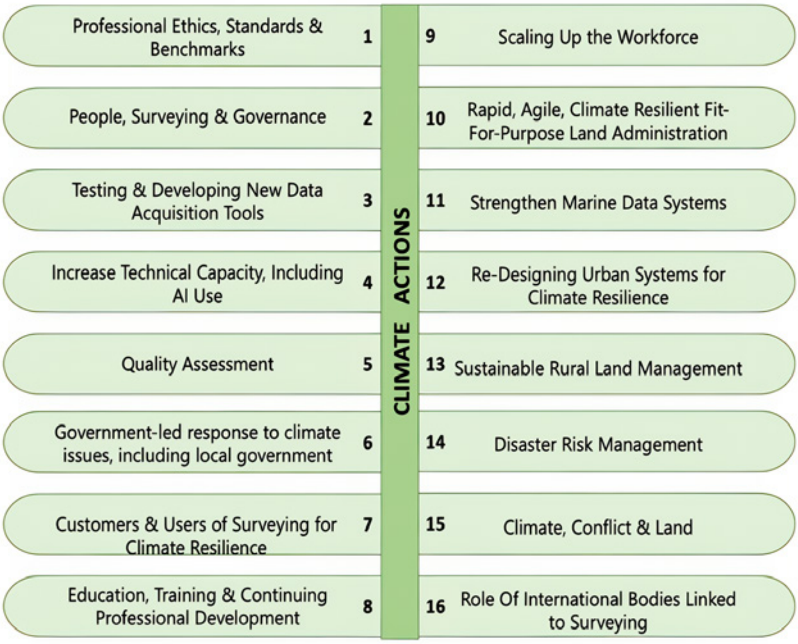
List of FIG Publications

For an up-to-date list of publications, please visit
www.fig.net/pub/figpub

ABOUT FIG

International Federation of Surveyors is the premier international organisation representing the interests of surveyors worldwide. It is a federation of the national member associations and covers the whole range of professional fields within the global surveying community. It provides an international forum for discussion and development aiming to promote professional practice and standards.

FIG was founded in 1878 in Paris and was first known as the Fédération Internationale des Géomètres (FIG). This has become anglicised to the International Federation of Surveyors (FIG). It is a United Nations and World Bank Group recognised non-government organisation (NGO), representing a membership from 120 plus countries throughout the world, and its aim is to ensure that the disciplines of surveying and all who practise them meet the needs of the markets and communities that they serve.



Humanity is dealing with a global climate crisis, with disproportionate impact on vulnerable regions, countries and people especially in the global south. Surveyors have a major role to play supporting the adaptation and mitigation of climate impacts at the global, national and local levels. They can support the achievement of the climate goals and environmental sustainability, economic growth and the land rights of people. Practical surveying actions, methods and tools for climate resilience, for land, water and marine are identified in this publication.

Long-term geospatial and hydrospatial and land administration systems data collection are foundations for territorial governance, in the context of climate resilience. This data links the physical, legal, economic and environmental dimensions. It provides vital information for: Climate-related policy development; Long-term climate monitoring and management; Identification of risks; Adaptation and mitigation measures; Effective land, water and marine management; Support to decision-makers managing the climate crisis. New technologies such as geospatial databases, historical and current Earth Observation (EO) data, large time series data analysis, AI tools, and other spatial and temporal innovations have enhanced the surveyors' critical role in the management of climate impacts.

Many surveyors in the industry have traditionally supported the USD287.6 trillion global residential real estate market. The climate crisis is creating opportunities for surveyors, government, the private sector, academia and industry to move to new business models that support climate resilience. The development of these business models is now a growing industry able to support multiple workflows going beyond business as usual. Surveyors use of geospatial technology is evolving rapidly to meet climate and disaster challenges, also as there are new markets for their skills. Solutions need to cross the digital divide of the global north and global south to ensure global and national environmental goals are met for people and the planet.

ISBN 978-87-93914-30-8 (pdf)