Application of science, technology and innovation solutions to increase participation in climate change adaptation

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Abstract

The application of science, technology, and innovation (STI) solutions is crucial for increasing participation in climate change adaptation. This case study analyses Germany's best practices in utilizing STI to address climate change adaptation, including climate-resilient infrastructure development, climate information services, advanced modelling, public information campaigns, technology transfer, integration of climate change adaptation in regulations, research and development, urban climate modelling, and cross-cutting instruments. The internal validity of these best practices is assessed based on their effectiveness, reliability, and consistency, while the external validity considers their relevance and applicability in diverse contexts. By continuously evaluating their validity and sharing knowledge, countries and stakeholders can advance their climate change adaptation efforts for a more resilient and sustainable future.

As part of the EU-funded AGORA (A Gathering place to cO-design and co-cReate Adaptation) project, we analysed participatory elements in national climate change adaptation policies. We determined that the application of science, technology, and innovation (STI) solutions plays a crucial role in increasing and enhancing participation in climate change adaptation. By leveraging advanced technologies, scientific research, and innovative approaches, it becomes possible to engage a wider range of stakeholders, improve decision-making processes, and implement effective adaptation measures.

In this case study, we discuss best-practice solutions we encountered in German policies as well as their internal and external validity. Our analysis was based on all German climate policies having climate change adaptation as their major focus starting in 2020 extracted from the Climate Laws of the World Database (in total, nine policies)[1].

STI best practices

This section delves into a comprehensive analysis of various initiatives undertaken by Germany to address climate change adaptation through STI solutions. Germany's proactive stance in developing climate-resilient infrastructure serves as a prime example of utilizing advanced engineering techniques, such as green infrastructure and resilient building materials, to mitigate the impacts of extreme weather events. Additionally, the country's emphasis on climate information services, advanced modelling, public awareness campaigns, technology transfer, integration of climate adaptation in regulations, and research and development underscores its holistic approach towards fostering climate resilience.

1. Climate-resilient infrastructure development: Germany's efforts in developing climate-resilient infrastructure provide a concrete example of applying STI solutions. This includes the use of advanced engineering techniques, such as green infrastructure, resilient building materials, and innovative urban planning to mitigate the impacts of extreme weather events. For instance, the integration of green roofs, permeable pavements, and sustainable drainage systems in urban areas enhances resilience to heavy rainfall and urban heat islands.

The effectiveness of these measures can be internally validated through comprehensive risk assessments, engineering simulations, and monitoring of infrastructure performance during extreme weather events.

These practices can serve as a model for other countries facing similar climate challenges, especially in urban areas prone to flooding and heat stress.

2. Climate information services and decision support systems: The development of climate information services and decision support systems, such as the German Climate Preparedness Portal (KLiVO-Portal), demonstrates the use of STI to enhance public

[1] Immediate Climate Adaptation Programme; Measures Programme for the Implementation of the Agenda on the Adaptation of Land Use, Land-Use Change, Forestry, Fisheries and Aquaculture to Climate Change; Forest Strategy 2050; Federal Action Plan on Nature-Based Solutions for Climate and Biodiversity; Arable Farming Strategy 2035; Climate Action Program 2030; Eighth National Communication and fifth Biennial Report of the Federal Republic of Germany under the United Nations Framework Convention on Climate Change; Germany's Recovery and Resilience Plan; Action Plan for the Dialogue and Work Process on the Middle Class, Climate Protection and Transformation.

awareness and support informed decision-making. These platforms provide access to climate data, risk assessments, and adaptation strategies, empowering stakeholders to make evidence-based decisions.

The accuracy and reliability of climate data and risk assessments can be internally validated through scientific verification and validation processes.

Similar platforms can be implemented in other regions to provide tailored climate information and support adaptation planning at local and regional levels.

3. Advanced climate modelling and scenario development: Germany's utilization of advanced climate models and scenario development, such as the simulation calculations based on climate scenarios, showcases the application of STI to assess future climate impacts and inform adaptation strategies. These models enable policymakers to anticipate potential climate risks and develop proactive adaptation measures.

The accuracy and robustness of climate models can be internally validated through peer-reviewed scientific assessments and model intercomparison studies.

The use of advanced climate modelling can be extended to other regions to assess the potential impacts of climate change and inform adaptation planning globally.

4. Public information campaigns and education initiatives: The Climate Action 2050 information campaign and education initiatives for sustainable development exemplify the use of STI to raise public awareness and build capacity for climate change adaptation. These campaigns leverage innovative communication strategies, digital tools, and educational programs to engage citizens, businesses, and policymakers in climate action.

The effectiveness of these campaigns can be internally validated through audience engagement metrics, knowledge assessments, and feedback mechanisms.

Similar public information campaigns and education initiatives can be implemented in other countries to foster a culture of climate resilience and empower communities to take proactive adaptation measures.

5. Technology transfer and capacity development: Germany's focus on technology transfer and capacity development in bilateral cooperation projects demonstrates the application of STI to build adaptive capacity in developing countries. By transferring innovative technologies and knowledge, these initiatives contribute to enhancing resilience and promoting sustainable development in vulnerable regions.

The impact of technology transfer and capacity development can be internally validated through project evaluations, knowledge transfer assessments, and capacity-building indicators.

The principles of technology transfer and capacity development can be applied in international cooperation efforts to support climate change adaptation in diverse socio-economic contexts.

6. Integration of climate change adaptation in technical regulations and standards: The measure to integrate climate change adaptation within technical regulations and standards showcases the application of STI to mainstream adaptation considerations into infrastructure and building codes. By incorporating climate-resilient design principles, these regulations contribute to enhancing the long-term resilience of critical infrastructure and built environments.

The effectiveness of climate-resilient design standards can be internally validated through engineering assessments, performance evaluations, and compliance monitoring.

Similar approaches can be adopted by other countries to integrate climate change adaptation into their regulatory frameworks, ensuring that infrastructure development aligns with climate resilience objectives.

7. Research and development on mitigation and adaptation technologies: Germany's focus on research and development of mitigation and adaptation technologies demonstrates the application of STI to drive innovation in climate change adaptation. This includes initiatives to develop and deploy sustainable technologies, such as renewable energy systems, climate-resilient agricultural practices, and eco-friendly building materials.

The efficacy of these technologies can be internally validated through scientific testing, field trials, and performance evaluations.

The knowledge and technologies developed can be shared globally to support climate change adaptation efforts in diverse geographical and socio-economic contexts.

8. Innovative urban climate modelling and environmental data integration: The lead initiative on local climate and environmental models for future cities and regions exemplifies the application of STI to develop advanced urban climate models and integrate environmental data. By simulating urban climate

processes and integrating diverse environmental parameters, these models support evidence-based decision-making for climate-resilient urban planning and infrastructure development.

The accuracy and reliability of urban climate models can be internally validated through model validation exercises, data quality assessments, and sensitivity analyses.

Similar initiatives can be replicated in other urban areas to support climate-resilient urban development and enhance the adaptive capacity of cities worldwide.

9. Cross-cutting instruments and measures for climate change adaptation: The use of cross-cutting instruments and measures, such as the development of storm-risk information for the public and the refinement of climate information services demonstrate the integration of STI to enhance public awareness, improve risk communication, and support evidence-based decision-making in climate change adaptation.

The effectiveness of these measures can be internally validated through stakeholder feedback, risk communication assessments, and knowledge dissemination evaluations.

Similar cross-cutting instruments and measures can be implemented in other sectors, such as public health, agriculture, and disaster risk reduction, to enhance climate resilience and support adaptive decision-making.

Discussion

The internal validity of these best practices can be assessed based on their effectiveness, reliability, and consistency in achieving their intended objectives. This involves rigorous scientific evaluation, data validation, and performance monitoring to ensure that the STI solutions contribute to meaningful outcomes in climate change adaptation. Additionally, internal validity can be strengthened through peer-reviewed research, stakeholder engagement, and continuous improvement processes to refine and optimize the application of STI in adaptation initiatives.

External validity refers to the generalizability and transferability of these best practices to diverse contexts and settings. It involves assessing the relevance and applicability of STI solutions in different geographical, socio-economic, and cultural environments. By sharing knowledge, best practices, and lessons learned, the external validity of these initiatives can be enhanced, enabling other countries and regions to adapt and implement similar approaches to address their specific climate challenges.

Policy recommendations / conclusions

The application of science, technology, and innovation solutions in climate change adaptation is essential for building resilience, enhancing participation, and fostering sustainable development. The best practices highlighted in this case study demonstrate the diverse ways in which STI solutions are being leveraged to address climate challenges. By continuously evaluating their internal and external validity and identifying opportunities for additional applications, countries and stakeholders can further advance their climate change adaptation efforts, ultimately contributing to a more resilient and sustainable future.

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