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Transformative Adaptation Approaches and Climate Change Resilience, Preparedness and Sustainability

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Abstract

This article provides a framework for building climate change resilience and climate change preparedness, to explain transformative adaptation approaches as a response to climate change. Building capacity in various dimensions, including structural, communal, individual, and urban planning, is directly related to transformative adaptation and the achievement of the United Nations Sustainable Development Goals. How can governments and communities develop transformational adaptation policies that foster collective and collaborative disaster risk management reform, and

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build resilient communities in the face of climate change? This investigative research, carried out in an attributive and causal way, discusses scenarios of climate change preparedness and resilience. The article is significant because it combines insights from environmental sciences, social sciences, and behavioural sciences into how to execute adaptation programmes and the effects of climate change. Following discussion of a set of conditions for transformative adaptation, the topics of inclusive governance, capacity-building strategies, incorporating climate change activities into sector and urban planning, and anthropogenic variables that affect individual willingness to change social behaviour are explored.

Key Words Inclusive governance; willingness to act; capacity building; innovation; empowerment; knowledge cocreation

JEL: Q56, Q58

1. Introduction

The five pillars for action presented at the 27th United Nations Climate Change Conference (COP27) are: adaptation to enhance resources for implementing adaptation measures; ambition to strengthen policy action; the Paris rulebook to hold countries accountable; loss and damage to secure a dedicated new financial facility; and finance to scale up high quality finance. Paragraph 25 of the Cancun Agreement COP16 Decision describes climate change as a slow onset, transformational, environmental phenomenon characterized by temperature increases, ocean acidification, rising sea levels, glacial retreats, salinization, land deforestation and degradation, and biodiversity loss. Despite optimistic perceptions of sink functions to reduce global emissions, facts and figures reported by the Intergovernmental Panel on Climate Change (IPCC) (2014) show that human climate change risks will continue to grow in the coming decades. Rapid growth, urbanization, community lifestyles, and anthropogenic activities are major contributors to increases in the frequency of heat related events, excessive greenhouse gas emissions, and urban thermal stress (Lin et al., 2021). Responses to climate change are divided into adaptation efforts, being prepared to avoid climate change impacts, and mitigation efforts, avoiding impacts through action (Campanella et al., 2012). Mechler et al. (2019) classify climate change impacts according to whether the losses and damages could be “unavoided” due to financial, technical, or political limitations, or “unavoidable” regardless of further mitigation and adaptation measures.

Transformative adaptation, from an ecological or social-ecological perspective, is linked to sustainable and resilient development, simply because when adaptation policy options are exhausted new perspectives are required to provide new options, including ecological transitions and innovation in primary economic systems and water management systems. Transformative adaptation is driven by radical alterations in systems, activities, and interactions, reducing the root causes of climate change impact, and working to find long term, sustainable and resilient solutions (Wahid et

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al., 2017). Transformative adaptation policy is enforced to minimize or avoid the losses resulting from climate change and is dependent upon the capacity building of governments and communities to support long-term sustainable resilience to climate risk (Roberts and Pelling, 2020). Brownstrein et al. (2022) show that, although community behavioural changes are an important factor leading to transformative adaptation, government intervention is required for individuals to be capable of responding equally to the impacts of climate change simply because climate change impacts are not experienced equally.

This article investigates transformative adaptative approaches as a response to climate change, in terms of climate change preparedness and climate change resilience, to offer a framework for climate change preparedness and explain the importance of transformative adaptation. Transformative adaptation is closely linked to capacity building in several dimensions: structural, community, individual behaviour, and urban planning. How can governments and communities develop transformational adaptation policies that create collective and collaborative disaster risk management, build resilient climate change communities, and fulfil the United Nations Sustainable Development Goals (SDGs)? The article is significant as it integrates natural science, social science, and behavioural science findings regarding the effects of climate change and the implementation of adaptation policies. Previous studies focus on specific disciplines, such as social science.

The research problem is conveyed through the difficulty of searching for a holistic, integrated research method in published scholarly research related to transformative adaptation. There is a gap in the indicators used for assessing the performance of transformative adaptation progress and adaptation approaches in general. For example, although the climate change performance index (CCPI), indicates the highest ranked countries, Denmark, and Sweden in 2022, their overall climate change performance is not high. The world map shows that, to date, no country performs well enough in the CCPI.

2. Research Methods

The article uses literature analysis, reviewing scholarly output from the Scopus and Google Scholar academic databases. Investigative research is conducted in an attributive and causal manner, examining scenarios of climate change preparedness to understand the relationship between climate change preparedness, climate change resilience, and transformative adaptive policy.

The study measures many entities and assesses global research performance in line with SDG13, using SciVal, a tool made available by El Sevier. SCI data analytics and performance indicators are based on the Scopus database, the biggest abstract and citation database of peer-reviewed literature in the world, which indexes academic papers from more than 5,000 publishers. To help end-users understand the research conducted by many institutions and researchers, in many nations, the product team has

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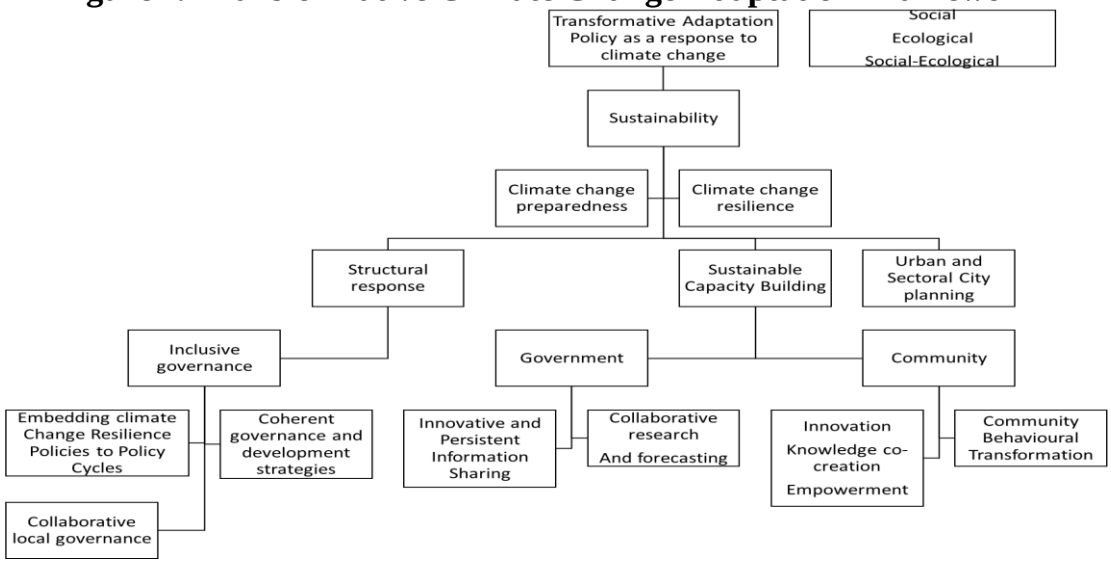
established designated research areas in SciVal for each SDG. The research areas are based on the Scopus search results. Each search query's complete technique and results are published openly on Mendeley. Research performance is determined by the output of the chosen entity, which could be the entire world, a specific nation, an institute or an actor. The time of interest in this study is the last five full years plus the current unfinished year, or 2018–2022, with worldwide research of SDG13: Climate Action (2021) in all categories of publication, as of 17 May 22. The search returned 252,857 articles with a field-weighted citation impact (FWCI) of 1.08 and a distribution of 71.6% in Q1 journals, 16.2% in Q2, 6.8% in Q3, and 5.5% in Q4. The scholarly output increased year over year, from 2,369 publications in 2018 to 32,230 publications in 2022. There is a gap in climate change articles about business, management, and accounting (2.2%), social science (6.7%), and other (9.4%) topics. Engineering makes up 10.8%, agricultural and biological sciences 8.3%, and environmental sciences 20.6%. Planning and development research makes up 43.1% of the social sciences disciplines, followed by general social sciences 6.8%, development 7%, education 3.6%, and urban studies 4.2%.

In sequence, the article proposes a framework for understanding transformative adaptation to climate change, as illustrated in Figure I, in terms of climate change preparedness, resilience and sustainability. A set of transformative adaptation conditions are discussed, followed by inclusive governance, capacity building techniques, climate change actions embedded in urban and sector planning, and anthropogenic factors based on willingness to act to change community behaviour. The limitations of the study include some questionable quality-based judgemental transparency issues.

Figure I: Transformative Climate Change Adaptation Framework



Source: The author.

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Climate change sustainability is an accumulative process of climate change preparedness facilitated by climate change resilience through capacity building. Climate change preparedness implies structural preparedness, community preparedness and urban planning. Pathways to transformative climate adaptation are divided into enhancing knowledge on transformative climate adaptation, building on preparedness, resilience, promoting sustainability, structural capacity building, inclusive governance, community capacity building, sectoral and city planning capacity building, and individual behavioural changes.

3. Enhancing Knowledge of Transformative Climate Adaptation

3.1 Transformative Climate Adaptation: Responses to Adverse Impacts of Climate Change

Adaptative strategies build on one another, and an alteration in one subsystem leads to adjustments in others. Adaptative strategies are applied by governments, international organizations, communities, and individuals, locally, regionally, and globally. Transformative adaptive approaches require collective effort. Coping adaptative strategies do not alter existing social or ecological features. They are maintenance responses to mild climate change impacts (Kates et al., 2012). Community based behavioural, social, ecological coping responses to flood damage include small farmers replanting crops to sustain their food security in Indonesia and Madagascar (Rakotobe et al., 2016). Incremental adaptation strategies are more anticipatory than coping adjustments and build on resilience to accommodate change. They include changing agricultural or land management practices, irrigation systems, combining natural and chemical fertilizers, and adapting to agroecological climate change impacts (Nguyen et al., 2013).

Transformative adaptation is described in the United Nations preamble to the SDGs, the Green Climate Fund Mandate, and Article 7 of the Paris Agreement, as a transformative paradigm and a step towards a sustainable and resilient climate development pathway, linking greater adaptation requirements to greater adaptation costs (UN, 2018; UN, 2015; UNFCC, 2012). Transformative approaches include climate change preparedness goals such as: (1) enhancing resilience; (2) promoting sustainability; (3) reducing climate change risks; and (4) embedding risks in implementation. Transformative climate change approaches are conducive to capacity building in its structural dimension at the community level through urban planning. Transformative climate adaptation approaches have the characteristics given in Table I whether applied to governmental policies and strategies, communities, or sector and urban planning.

Table (I): Characteristics of Transformative Climate Adaptation Approaches

Characteristic	Explanation
Restructuring	Shift in function and interaction
Path Shifting	Shift to sustainable, resilient pathways

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Innovative	Shift to new states and activities not previously experienced
Persistent	Shift to long term impacts
Multiscale	Impacts are across multiple scales, societal levels and governance levels
Systemwide	Transformation happens on a large scale with systematic changes across whole regions, ecosystems, landscapes, communities or geographies

Source: The author, from Brooks et al. (2011).

3.2 Conditions for Transformative Adaptation

The following conditions for transformative adaptation are compiled by the author from various scholarly works, such as Thornton and Comerti (2017), Colloff et al. (2017) and Blythe et al. (2018).

Condition #1: Transformative adaptation is enforced as a win-win, development measure, regardless of the high degree of climate change uncertainty. Therefore, the timing and the extent of enforcement are important. Transformative adaptation is collectively implemented by ensuring fundamental changes in structure, government policies, urban and sectoral level planning, and individual behavioural changes. The results are sound, from one or all the social, ecological, and socio-ecological perspectives.

Condition #2: Transformative adaptation is an option when the limits and thresholds of existing systems of incremental approaches have been exhausted, demonstrating unviability. The cost of fixing such thresholds is most likely higher than suggesting a new alternative method. The threshold depends on the degree of resilience and vulnerability of the system.

Condition #3: When systems based on incremental adaptation become maladaptive, inadequate or unsustainable, transformative adaptation is implemented. Examples of maladaptation include irrigation system expansions that are unsustainable due to water scarcity resulting from climate change, construction of hydropower with streamflow declines hindering the operational process, increases in economic activity dependent upon non-renewable resources, and resources threatened by changes in climate such as at-risk fisheries which have reached maximum sustainable yields**.**

Condition #4: When incremental adaptations become maladaptive, there is a phased out transitional approach, where incremental changes are pursued in the short term, followed by a transformational process, which, at first, overlap, until it is tested for longer term sustainable measures and established in an appropriate policy format, developing alternative livelihood strategies.

Condition #5: The larger the vulnerability in regions, populations, and ecological resource systems due to physical location, such as low-lying landscapes, socio-

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economic factors, such as poverty, or water-stress affecting agricultural systems, the more sustainable it is to implement transformative adaptation.

Condition #6: Transformative adaptation in climatic and environmental conditions is long term and is intended to be sustainable. It is a response to severe changes that go beyond the range of current predictions, amplified by global climate change impacts, locally, regionally, and globally. Transformative adaptation becomes viable when resilience building (vulnerability reduction), which is associated with incremental adaptation, is unlikely to expand with sufficient rapidity for coping.

Condition #7: The time and speed elements of transformative adaptation should be prioritized in the portfolio of adaptation strategies, to ensure affirmative and enforced fundamental change.

Condition #8: Transformative adaptation requires long-term human and financial plans that require political and social support. This is a challenge due to power imbalances, social inequalities, dominant resistant-to-change actors benefiting from the current status quo and variations in governance self-interests.

Condition #9: Transformative adaptation requires future vision for the reconciliation of the trade-off between economic growth and low carbon emissions.

Condition #10: Transformative adaptation requires a better understanding of the inherent ecological value of things, with a focus on cultural values, ethics, religious backgrounds, and the economic value of things through willingness to pay, willingness to act and willingness to change.

Condition #11: Transformative adaptation is anticipatory in nature and depends on the creation of a sustainable enabling environment at the structural and societal level.

4. Climate Change Resilience and Climate Change Preparedness

Climate change preparedness operates with resilience, progressing from structural approaches, community behavioural transformation and comprehensive pre-, mid-, and post-shock responses, leading to the necessary policy response, implementation, and funding. Climate change resilience serves as a facilitator of climate change readiness and sustainability (Boda et al., 2021). Climate change resilience is a planning process to combat risk and maintain sustainability with long-term effects on welfare. From an ecological perspective, an alternative system exists as there is no single fixed equilibrium or system. Systems evolve and change (Holling, 1996). Socio-ecological systems are non-linear, complex and self-organizing, composed of multiple scales and actors. Hence, from an ecological perspective, an alternative system exists to backup systems as they evolve and change (Davoudi et al., 2012). According to the IPCC (2014), resilience is the ability to absorb and adapt to change while maintaining primary ecological, social, and socio-ecological functions and

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structures when exposed to climate risks. Climate change resilience is a facilitator of climate change preparedness, as it concerns the pre-, mid-, and post-shock plans for capacity coordination, delivery mechanisms and financing mechanisms (Catalano et al., 2020).

Measuring climate resilience is difficult due to domestic and external policy challenges, socio-ecological and biophysical datasets that are often lacking in emerging countries, and indices that measure broad common capacities and practices rather than specific preparation, recovery and adaptation implementations (Lindsey et al., 2018). Because objective resilience measurements are not currently possible, subjective resilience frameworks are used to measure community capacity to prepare, adapt, anticipate, and act against the effects of climate change shocks (Jones et al., 2015). The current climate change management system might be incompatible (not heading in the same direction) with new transformative adaptation processes. According to Tyler and Moench (2012), comprehensive and innovate resilience building is a sustainable approach to combatting climate change risks and cannot be achieved without capacity building to meet sustainability goals. This is seen in the tangible impacts of climate risk on food security and improving climate risk management is one strategy for achieving SDG2.

5. Inclusive Governance and Transformative Adaptation

5.1 Local Governments and Transformative Adaptation Strategies

Local governments have leadership roles in implementing transformative adaptation strategies simply by assessing local impacts and providing alternative solutions (Funfgeld, 2015). Building resilience is dependent upon the adaptive capacity of local governments in the determination of national climate change adaptation strategies. Tyler and Moench (2012) suggest a two-staged resilience planning framework: (1) comprehending vulnerabilities in the institutional, social, ecological systems and their subsystems; and (2) identifying actions, prioritizing, designing, implementing, and monitoring steps towards transformative adaptation.

5.2 Path-Shifting, Multi-Scale and Systemwide Inclusive Governance as a Transformative Adaptation Approach

With transformative policy, governments are facilitators of multi-loop learning approaches, taking advantage of windows of opportunities with climate change effects and new development pathways such as political reforms, technological reforms, and development pathways. Systemwide governance arrangements for the purpose of action on climate resilience are expected to be inclusive with the governments as facilitators and reinforcers of structural climate change resilience, government and development organization cooperation, and government support for development cooperation. This is intended to expand successful progressive strategies for the most affected and most vulnerable individuals with equitable engagement of vulnerable

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stakeholders in decision making about climate resilience (Daze et al., 2019). The spread of transformational adaptation entails several levels of governance, participation in the political economy, a study of the motivations and interests of various stakeholders, and an examination of commodity chains from producers to consumers. Inclusive governance is comprehensive and entails several participatory governance levels, taking into consideration the motivations and interests of various stakeholders, commodity chain producers and consumer patterns (IPCC, 2018). Explicit integration of the steps into a country's policy cycles is linked to the level of public participation, and adaptive and flexible governance (OECD, 2020). Insights from the Sustainable Development Impact Meetings of 2022, Al-Mashat emphasized the importance of engaging all stakeholders to inclusive governance in terms of community, philanthropy, individual responsibility and financing (World Economic Forum, 2022, Sept 20). Skinnari prioritized a holistic and inclusive digitalized strategic approach to solutions of climate change adaptation (World Economic Forum, 2022, Sept 20).

Undertaking inclusive governance should be done in steps, within policy cycles, using a checklist of transformative climate change:

1. Embedding resilience against climate change risk policies into inclusive growth (Table II),
2. Collaborative facilitation of local governance at all levels (Table III),
3. Coherent governance mechanisms in development agendas for adaptive decision making (Table IV).

Table (II): Embedding Climate Change Resilience Policies into Inclusive Growth Policy Cycles

Government as a facilitator and reinforcer of climate change
• Engaging the community, specifically individuals, by identifying the social, economic, and environmental risks. • Encouraging stakeholder participation in local formal and informal policy making. • Engaging non-state actors and the private sector in transparently assessing climate risks and challenges.
Government and development cooperation
• Enhancing comprehension of the adverse socio-economic effects of climate risk to reinforce the planning and implementation process of climate resilience policies. • Integrating knowledge of climate change into legislation, incentives and motivations among many players and formal and unofficial institutional obligations. • Monitoring and evaluating the embedding of climate change resilience in policy cycles.
Government with support from development organizations
• Recognizing long-term climate related risks and opportunities and their effects on sustainable development. • Revising the causes of structural and community vulnerabilities.

Source: the author.

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Table III: Collaborative Facilitation of Local Governance at All Levels.

Government as a facilitator and reinforcer of climate change
• Engaging in national climate change strategy dialogues among ministries, local communities, urban planning engineers and demographic specialists.
Government and development cooperation
• Highlighting positively impactful climate change practices by local actors. • Enhancing and expanding various community practices through training and information sharing.
Government with support from development organizations
• Building on current local government structures to connect climate resilience with the decision-making procedures for regional socioeconomic growth. • Expanding on the government's decentralization measures to encourage local action on climate resilience.

Source: the author.

Table IV: Coherent Governance Mechanisms in Development Agendas for Capacity Building

Government as a facilitator and reinforcer of climate change
• Reiterating high-level political support and engagement in sector transparent policy coordination. • Strengthening and re-enforcing existing regulatory measures by communicating clear and accountable incentives to support climate resilience and minimizing variations in policy objectives.
Government and development cooperation
• Developing methodological and supportive tools to enhance robust decision making through a better understanding of climate forecasting techniques, climate change performance indicators and collaborative research. • Supporting resilient inclusive knowledge cocreation and community empowerment. • Modifying existing plans and measures to embed climate resilience whenever possible.
Government with support from development organizations
• Assimilating national level climate change policies into local development plans, agendas and strategies. • Constructing governance arrangements to support flexible and adaptive decision making in the context of uncertainty. • Lessening information leakage gaps between sectors, ministries and agencies to integrate climate resilience across portfolios, aligned with objectives and other policies on climate change and disaster risk reduction. • Improving efficiency in the use of financial and human resources.

Source: The author.

6. Sustainable and Inclusive Climate Change Capacity Building

Notwithstanding the increased United Nations Framework Convention on Climate Change (UNFCCC) focus on capacity building since 1992, there is limited agreement on frameworks for strengthening the design and implementation of adaptation efforts

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(Alpízar et al., 2019). Various delivery mechanisms could be used by policymakers to build a climate change capacity learning environment, which include shared learning dialogues, learning through collaborative research, knowledge cocreation and empowerment. Governments are expected to invest in research, trial-and-error transformative adaption policies, strategies, and actions (Gardiner et al., 2019). A two-phase approach to creating community capacity relies on knowledge cocreation, the development of knowledge, as phase one, and the empowering of community actors, as phase two. By acknowledging the intrinsic significance of individual and community experiences in framing knowledge needs, policymakers can consider how to facilitate bottom-up responses to transformative adaptation strategies (Grabowski et al., 2019). One type of sustainable learning entails reorienting the focus from top-down knowledge transfer to social learning and collaboratively creating contextual understandings of how to effect change (Balazs & Lubell, 2014). In the presence of transformative adaptation, empowerment is the sustainable process that seizes windows of opportunity and gives actors the capacity to mobilize institutions and resources to achieve the goal of shifting to transformative adaptation, particularly when vulnerability is present (Avelino, 2017).

The proposed tools that could be used to facilitate shared knowledge are as follows:

#1: international intuitions' manuals and guidebooks to assist local governments in climate change management, local policy implementation, urban and sectoral planning, learning through monitoring, evaluating and follow-up.

#2: climate resilience toolkits that provide steps to embedding resilience in the face of climate hazards.

#3: international, regional, and local inclusive and participatory workshops, conferences, and questionnaires to ensure the inclusion of public policymakers, experts, academics, and engineers.

#4: climate change resilience networks for city planning, policymaking, and community behavioural change, to engage various stakeholders in communication and mutual learning.

#5: vulnerability assessment reports to understand the direct and indirect impacts of climate change on urban systems, communities, individuals, and sectors.

#6: city resilience and planning strategies designed to implement resilient development.

#7: climate service partnerships providing climate-informed decision making, climate-smart policy planning and smart cities to oversee producing, translating, transmitting, and utilizing climate knowledge. The ASPIRE project is an example of a climate service partnership where collaboration between the World Bank, DFID, national

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social protection organizations and climate stakeholders focuses on seasonal forecasts, working on extending lead time for early climate preparedness action, and acknowledging better use of observational data to spur climate information related resilience in Africa and the Sahel region (Boyd et al., 2014).

#8: coordinated efforts of national meteorological agencies, international meteorological organizations, and regional climate centres to produce observed and anticipated weather and climate data, as well as imminent hydroclimatic risks at the national level. By addressing inconsistencies in seasonal and extended sub seasonal climate forecasts, knowledge cocreation is accomplished. An effective strategy for embedding observed trend information into predictions, reducing model biases, and boosting forecast skills and reliability is proposed to address the trend mismatch problem in seasonal climate forecasts (Shao et al., 2021).

#9: collaborative research techniques for creating out-of-the-box perspectives and sharing old ones.

7. Sectoral and Urban planning Capacity Building

Transformative adaptative urban city planning through the built sector and sectoral planning is discussed. Moser and Luers (2008) evaluate preparedness to adapt to climate change risks, arguing that planned transformative adaptation to climate change begins with the combined awareness of public and private sector decision-makers of how climate change may impact their current and future practices. Actioning this awareness is dependent on the decision-maker's capacity to analyse climate change information and use it to develop initiatives, strategies and plans. In conjunction with willingness and incentives, this understanding can translate into practical action. The built environment, in this context, includes various professionals, with distinct professional codes of conduct, policy making bodies and governing policies.

7.1 Climate Change Preparedness and Sectoral Planning

Triggering climate change preparedness in sectoral planning is directly related to high levels of awareness. However, this is a relative concept, dependent upon the kind of climate risk associated with the nature of the landscape. Numerous empirical studies in the fields of urban planning and construction planning reveal high levels of awareness of climate risks related to effects on water systems and rising sea levels. For example, Uittenbroek et al. (2013) find that Dutch planners are aware of the risks of climate change to water systems, while British planners are aware of the risks of coastal erosion (Young and Essex, 2020). On the other hand, Australian planners are aware of sea-level rise-induced coastal erosion (Gurran et al., 2013). Low levels of knowledge about potential threats from climate change relative to actual risks are observed (Hurlimann et al., 2019).

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Climate change preparedness concerns, in the property planning sector, include several questions such as: (1) How knowledgeable are real estate companies regarding the dangers of climate change and adaptation options, particularly transformative adaptation? (2) How could real estate companies, brokers and valuers locate the necessary data to properly account for and integrate climate change risk into project valuations and decision making? (3) To what extent are leadership roles, information sharing, capacity building and knowledge sharing across governments, academia and other sectors supporting sectoral risk awareness of climate change?

7.2 Sectoral Transformative Adaptation in Social-Ecological Systems

Transformative adaptation in social ecological systems involves a transition that shifts functions, interactions, and pathways of sustainability to long-term novel impacts on multi-dimensional levels, and is large in scale, fulfilling the conditionalities discussed.

In cities faced with high flood risks, urban planning examples of transformative adaptation in social-ecological systems include the revitalization of rivers, relocation of human activities in flood plains (as opposed to building channels and dikes), the shift from fossil fuels towards clean energy production, and the creation of multi stakeholder committees for managing water use quotas during scarcity (compared to top-down decisions). Another optional response to floods could be community transformative adaptive policies, transforming the social ecological system by relocating houses or crop fields to safer areas, or restoring previously degraded wetlands upstream. Another example of transformative potential related to rising heat stress and infrastructure damage could rely on increasing resilience through resistant buildings rather than the development of new land use plans which restrict the use of areas with high risk and mitigation potential.

Figure II and Figure III provide examples of transformative adaptation in the agricultural sector. When considering the four phases of an adaptation plan in the primary agricultural sector, there is a dependent link between the size of the human input and the size of the reaction to climate change. Moving from right to left, or from inaction to transformative adaptation, entails a change in the amount of time, money and effort invested, as well as a shift in the stakeholders and sectoral levels involved, from the original status quo to higher levels of uncertainty and risk, and a shift in values, assumptions, and framings.

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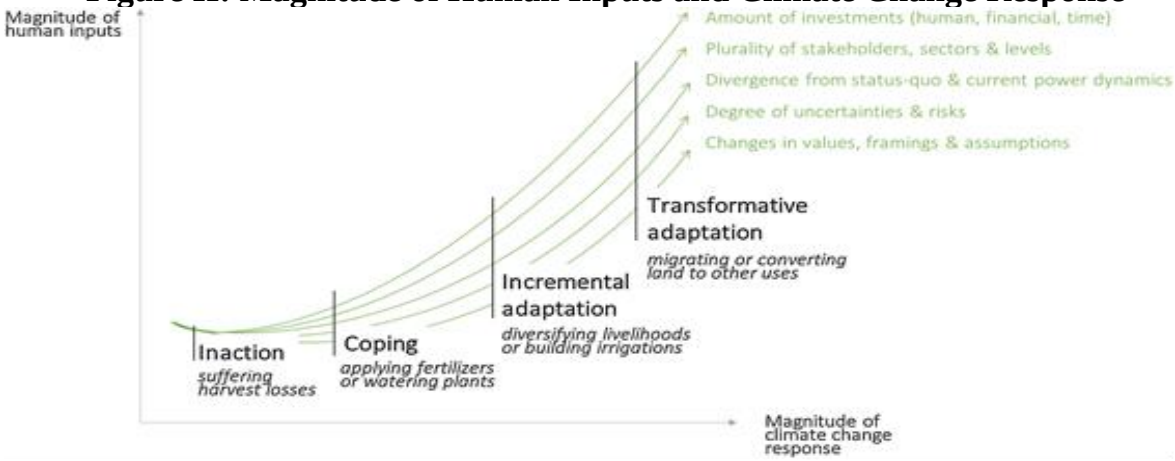
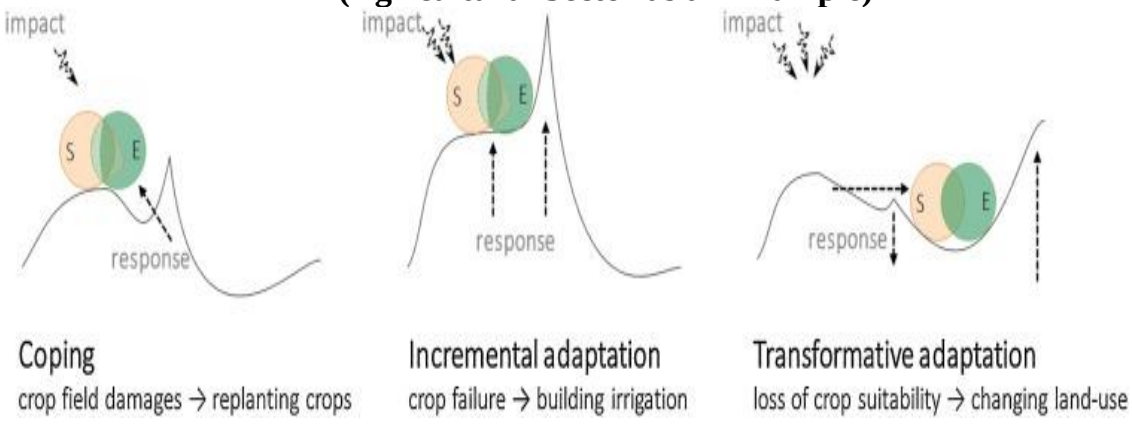
Figure II: Magnitude of Human Inputs and Climate Change Response



Source: Fedele et al. (2019)

As seen in Figure 3, farmers can alter systems in a variety of ways to sustain food security under shifting conditions, depending on the severity of the consequences of climate change and their capacity to adjust (illustrated by the dotted arrows). Farmers may choose to replant damaged crops as a coping technique, construct irrigation systems to lower crop failure risks in the future, or fundamentally alter the characteristics and qualities of the land use by implementing agroforestry or deforestation (transformative adaptation). To ensure crop sustainability and resilience, transformative adaptation modifies the existing system through a shift in land use. Sustainability boosts agricultural productivity and income, altering systems by reducing gas emissions and transforming to climate smart agriculture and sustainable greenhouses.

Figure III: Alternative Social Ecological Systems to Adaptation Systems (Agricultural Sector as an Example)



Source: Fedele et al (2019)

To identify practical manufacturing technologies and techniques, more site-specific analyses are needed. The development from traditional agricultural improvement methods to inventive adaptation measures which bring about new production

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management levels, shifts in location, and shifts to new resource systems address productivity losses connected to damage associated with climate change.

8. Community Behaviour and Transformative Adaptation Policy

8.1 Anthropogenic Potential Drivers for Climate Change Adaptation Policy

There is a direct relationship between anthropogenic drivers and support for adaptation when considering local exposure and local policy (Fletcher et al., 2020), through individual expectations for future occurrences and the impact and scale of climate and weather extremes in a particular area. When individuals face or fear facing resource scarcity, they respond either exclusively or parallelly, by relocating (migrating out), by becoming more flexible and mobile in exploiting spread resources or becoming sedentary and intensifying their innovation for productivity (Brooks, 2011). Community exposure to climate risk triggers greater transformational behaviour in support of adaptation policies. Reynaud et al. (2013) measure individual climate change exposure by the number of times an individual witnesses a climate change risk directly or indirectly. Social-psychological factors can predict transformative adaptation behaviour via indicators such as risk perception, perceived social norms and response efficacy. Scientific literature identifies positive and direct relationships between climate change preparedness and risk perception. Risk perception is used to explain people's judgments, the psychological influence on their decision making and their reactions to events (Rana et al., 2020).

8.2 Behavioural Models for Transformative Behaviour

Embedding interdisciplinary behavioural models into policymaking helps the transition to sustainable transformative adaptation. From an economic perspective, humans are capable of both rational and non-rational decisions, and both are valuable in different contexts. Primarily, rational choice models consider decisions to be based on cost benefit analysis, maximizing expected value and self-interest. In parallel, behavioural change is sometimes based on nonrational or unpredictable behaviour, as stated in Thaler and Kahneman’s prospect theory (Osberghaus 2017). In anthropogenic terms, De Young’s (1993) set of evaluation metrics tests behavioural transformation according to: (a) speed of change, or how fast behaviour is adopted during policy interventions; (b) reliability, or how consistent behavioural change is following policy interventions; (c) particularism, or how sustainable behavioural change is tailored to meet specific subgroups; (d) generalizability, or how effective a policy intervention results in individual change agents spreading transformative behavioural change; and (e) durability, or how sustainable behavioural change is, its level of maintenance without continual intervention, and whether it is adopted as common practice. Models originally used for understanding health behavioural changes could be tailored into qualitative surveys to conceptualize changes in human behaviour related to climate change risk. For instance, the transtheoretical model (TTM) measures human-staged behavioural transformational change using several

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indicators: (a) minimal climate change concern; (b) climate change concern with minimal planned action (associated with low costs(; (c) intermediate climate change concern, intention to take action to reduce one's emissions (the individual is consuming mental and time costs but the total behavioural cost may prevent them from actually taking action); and (d) advanced climate change concern, taking actual action to reduce individual emissions (high cost with strength in attitude) (Redding et al., 2015).

8.3 Behavioural Response Change - Psychological Community Measurement Tools as Behavioural Preparedness Measurement Tools

A combination of scales, indexes and qualitative-based questionnaires could be used to analyse the degree of community behavioural preparedness and willingness to change and act. Behavioural changes in individuals go through several emotional phases, starting with potential stress due to climate anxiety, risk perception and potential emotional concern, potential emotional reaction, and the willingness to act.

#1: Potential stress is accompanied by climate anxiety, negative emotionality, and depression. It could be measured by: (a) the Climate Change Anxiety Scale (CCAS), a measure of the cognitive emotional and functional impairment factors linked to climate anxiety; (b) an adapted version of the CCAS based on rumination depression scales with high scores indicating high levels of climate anxiety and lower scores indicating climate change denial (Wullenkord et al., 2021); or (c) the four-item patient health questionnaire to test for climate change anxiety and depression, generating average scores among all four items to indicate psychological distress (Clayton et al., 2020).

#2: Risk perception and potential emotional concern for adverse effects of climate change is a consistent predictor of climate change behaviour which could be measured using questionnaires, Likert-type responses, the Climate Change Concern Index (CCCI), and questions considering the potential effects of climate change (Roesch-McNalley et al., 2017). Measuring climate change risk perception is subjective and dependent upon individual ways of thinking, opinions, experiences etc.

#3: Potential emotional reactions are measured using perceived emotional valence and psychological distancing in four dimensions: spatial, temporal, social and hypothetical, using questionnaires and surveys based on Likert scales.

#4: ***Willingness to act based on psychological flexibility and inflexibility*** is measured by specific adaptation intentions, using either questionnaires, aggregate measures of mitigation and adaptation intention, or the Multidimensional Psychological Flexibility Inventory (MPFI) (Feather et al., 2022) to analyse the degree of psychological flexibility (PF) and psychological inflexibility (PI) evenly. Table V illustrates various examples of climate change risks, kinds of willingness to act, and transformative adaptive behavioural actions.

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Table V: Willingness to Act and Climate Transformative Adaptive Behaviour

Climate change risk	Individual willingness to act
Sea level rise	Relocation of settlements and large-scale economic activity. In risky areas, a shift away from water intensive agriculture and climate sensitive tourism to fewer sensitive activities.
Retreating rainfall	Abandonment of previous productive areas through migration, successive shifts in production systems and settlements.
Arid river areas	Occupation and exploitation of new water areas. In and out migration which results in concentration of populations in areas considered safe, leading to environmental deterioration and desertification (such as near the River Nile).
Extreme land aridity	Increase in mobility to exploit more sparsely distributed resources. Abandonment.
Disappearance of surface water sources such as cessation of rainfall and drying lakes	Adoption of irrigated agriculture using ground water.

Source: The author, using Brooks et al. (2011)

#5: ***Response efficacy,*** related to adaptation policy, is a moderating variable shaping respondents' support for adaptation and transformative policy, by which an individual perceives a certain action as capable of achieving its intended result, or not (Singh 2017). Policymakers could use response efficacy reports to conduct community behavioural transformative change, increase climate change preparedness and maintain sustainability, as shown in Table VI.

Table VI: Community Behavioural Transformative Change and Climate Change Preparedness

Before the disaster preparedness policy recommendations 1. General disaster preparedness planning and specific evaluation of disaster preparedness plans with participation of local people and communities. 2. Providing training opportunities with participatory events to develop knowledge and skills in disaster management.
During the disaster preparedness recommendations 1. Relief assistance plans provided by policymakers. 2. Better pro-social and pro-environmental individual attitudes. 3. Collective action among leaders and communities.
After the disaster preparedness recommendations 1. Fast-paced mobilization for disaster relief and environmental cleaning. 2. Timely review and lesson learning from disaster preparedness activities.

Source: The author.

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9. Conclusion

Transformative adaptation can make the transition from accepting change to actively embracing it and putting sustainable climate change responses into action easier. We need to look beyond the boundaries of recent climate variability to examine transformational changes related to rapid and severe changes in climate. This comes with its own set of difficulties, the dearth of data, the reliance on contemporary indicators rather than historical records, and the difficulty in determining the relationship between climatic, environmental, and social change. Numerous studies limit their analysis to the identification of temporal correlations between climatic and anthropogenic factors. This article analyses climate change preparedness, resilience and sustainability and proposes a framework for understanding transformative adaptation to climate change. It discusses the conditions for transformative adaptation, factors such as inclusive governance, techniques for building capacity, climate change action incorporated into urban and sector planning, and anthropogenic factors that cause changes in community behaviour. Policy recommendations for implementing transformative adaptation approaches are made, as follows.

Policy #1: Key actors are urged to restructure their systems, promote inclusive governance through participatory approaches, commodity chain engagement and collaboration among multiple stakeholders such as researchers, practitioners and policymakers for system-wide action that disseminates new practises such as bridging organizations, local leaders, and system of restructuring to facilitate transformative adaptation.

Policy #2: Transparency and collective sharing of information are necessary to avoid bottlenecks in willingness to change and willingness to act to change behaviour towards supporting transformative adaptation by individuals in communities.

Policy #3: Inclusive governance, additional investment in climate forecasting techniques, knowledge cocreation, community empowerment, interdisciplinary research, involvement at the national policy, programme and strategy level, and community participation are all needed to improve capacity building.

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