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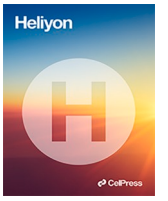

Research article

Innovative governance for transformative energy policy in sub-Saharan Africa after COVID-19: Green pathways in Egypt, Nigeria, and South Africa

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ABSTRACT

Learning from innovations that fail is imperative for innovations that succeed. The theoretical underpinnings for this innovative framing are reflexivity, transformative unlearning, and intelligent failure. This framework proposes a definition of "transformative governance" as governance that creates structural equities. Governments rebuilding their economies after the COVID-19 pandemic seek equitable green transformations; that are gendered, structural, and sustainable, learning from the implemented gender-sensitive responses (hereafter referred to as policy innovations). This paper argues that transformative practices, beliefs, values, assumptions, policies, and systematic learnings are complementary to post-crisis transformations. The aim is to promote systematic learnings from innovation governance failure regarding energy policy through the analysis of COVID-19 practices and the unlearning of policy innovation beliefs, values, and assumptions that are not transformative. I ask: how gender-equitable, structurally equitable, and green-transformative were the COVID-19 policy innovations? The study's approach is qualitative and situated within the constructivist research paradigm. It uses reflexive thematic analysis combined with innovative coded policy narrative and a transformative index-matching technique, to identify the gap within transformative interventions. The study included 58 policy innovations ($n = 58$) collected from the UNDP, KPMG, government reports, and news flashes from the three most populous nations in sub-Sahara Africa: Egypt, Nigeria, and South Africa. The study found that policy innovations were inequitable in terms of gender, structure, and sustainability whereas the derived transformative pathways are equitable and gender-transformative, structurally transformative, and green-transformative. The rationales behind a transformative approach to policy reflect the systemic failures across key areas: market dynamics, research and development, and green transformation. Policy innovators can align transformative pathways for innovative governance that implements transformative energy policy. To address the needs of multiple fragile and vulnerable identities, the derived post-pandemic framework is an intersectional plan with 10 policy learning pillars. The plan includes local energy transformation and reinforcement of energy justice components, such as the localization of the energy industry, community power, and social norms, including *Ubuntu,* which translates to "I am because we are." Reengagement in global supply chains requires South-South trade relations to be restrategized.

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Abbreviations

COVID-19	Coronavirus disease
SARS-CoV-2	The Virus that causes COVID-19
SSA	Sub-Saharan Africa
MSMEs	Medium, Small, and Micro Enterprises
MLICs	Middle- and Low-Income Countries
MNRE	Ministry of New and Renewable Energy (China)
PAYGO	Pay As You Go
GW	Gigawatt
EGP	Egyptian Pound
KW/h	Kilowatt hour
Q2	Second Quarter
CSR	COVID-19 Solar Relief Fund
REA	Rural Electrification Agency (Nigeria)
USD	United States Dollar
ECF	Energy Cultures Framework
R&D	Research and Development
HoH	Head of Household
IR	Industrial Revolution
ML	Machine Learning
HI	Historical Institutional perspective
RTA	Reflexive Thematic Analysis
GDP	Gross Domestic Product
AGI	Africa Gender Index
FiT	Feed in Tariffs
IPP	Investment Priorities Plan (Nigeria)
SIGI	Social Institutions and Gender Index
ETI	Energy Transition Index
UNDP	United Nations Development Programme
KPMG	Klynveld Peat Marwick Goerdeler
EBRD	European Bank for Reconstruction and Development
EU	European Union
GCF	Green Climate Fund
GVC	Green Value Chain
GEFF	Green Economy Financing Facility
EUR	Euro
SGFF	Special Green Facility Financing
cbm/d	cubic meters in depth
SHSs	Solar Home Systems
NDCs	Nationally Determined Contributions
ESP	Economic Sustainability Plan (Nigeria)
MTEF	Medium Term Expenditure Framework (Nigeria)
APP	Agriculture Promotion Policy (Nigeria)
NAP	National Adaptation Plan (Nigeria)
bps	basis points
ZAR	South African Rand
NGP	National Gender Policy (Nigeria)
HIV/AIDs	Human immunodeficiency virus
AfDB	African Development Bank
AFAWAZ	African Women in Business
ICTs	Information and Communication Technologies
AfCFTA	African Continental Free Trade Area
WTP	Willingness to Pay
ATP	Ability to Pay
GDTs	Globally Distributed Teams
PAYGO	Pay As You Go
XOF	African Financial Community Franc
ENDEV	Energizing Development
M-PESA	Mobile phone-based money transfer service, payments, and micro-financing service

Fintech	Financial Technology
AI	Artificial Intelligence
Industry 4.0	The Fourth Industrial Revolution
AEU	African Energy Utility
ASE	African Stock Exchange
m	meters
CP	Community Power
REIPPPP	Renewable Energy Independent Power Producer Procurement Programme (South Africa)
MW	Megawatt
RCT	Randomized Controlled Trial
The Muza 10-PLP_4IG_4TEP	The Muza 10-Policy Learning Pillars for Innovative Governance for Transformative Energy Policy

1. Introduction

If post-crisis transformation is to be successful, systemic learnings from innovation failures are imperative. Innovations that fail "innovation failures" and innovations that succeed, "innovation successes" inform systemic learnings. Research on coronavirus disease (COVID-19) has clearly articulated the negative effects of the pandemic on global supply chains and the failure of policy innovation to address the impending situation [1]. The first wave of SARS-CoV-2, the virus that causes COVID-19, spread globally between March and July 2020 [2], and a second wave began in September 2020 [3]. At the time of writing, a new variant has caused a third wave ravaging nations and regions of the Global South, such as India [4] and SSA. The coronavirus disrupted global supply chains for key sectors such as energy; food; water; health; education; and critical infrastructures such as railways, roads, ports and airports, mining cargo dealership, and electrification, among others. Governments placed billions of people under lockdowns within homes, communities, and national and sub-national borders. The blanket approach to lockdowns as a policy innovation amplified social inequalities in infection reductions due to existing gaps in health access, which affects marginalized groups, such as rural, and low-income communities, and population categories such as women, and children [5,6]. In countries where health systems are well-developed, such as Brazil, some inequalities in coronavirus recovery rates are structural: they are deeply rooted in histories of inequality that existed before COVID-19 [6,7]. Simultaneously, climate change is causing significant worldwide disruptions that require urgent action [8]. As governments and international organizations try to rebuild after the COVID-19 pandemic, it is important to address the disruptions, complexities, stagnations, failures, and inequities created and amplified by external shocks like COVID-19 and climate change.

For nations and communities seeking to recover, rehabilitate, and reconstruct to "build back better" after the pandemic, transformation needs to be sufficiently grounded in systematic innovation learnings or unlearnings. Transformation concerns adjustments to factors that threaten success, such as abrupt changes caused by crisis events. To mitigate the impacts of COVID-19 at the individual, institutional, and system levels, the literature has outlined practices that can be transformed. The examination of COVID-19 practices is vital for systematic innovation learnings or unlearnings [9–11]. It motivates advanced transformation. Globally, nations have introduced COVID-19 gender-sensitive responses (hereafter referred to as policy innovations) to address gender-specific fragilities and vulnerabilities among affected population groups. These policy innovations aim to alleviate the suffering, protect social, labor, finance, and economic rights, and promote economic recovery. By determining positive or negative societal impacts, the analysis of emergent practices contributes to energy research, policy, and practice that can promote the adoption of low-carbon green technologies, green transitions, green transformations, and green growth [12–16]. Concurrently, South-South trade in green technologies, which had been promised before COVID-19, was disrupted due to shocks in the Chinese energy sector [17,18]. The projected 8 % decline in global energy demand negatively impacted energy transitions [19]. The slowdown in energy projects has exacerbated the preexisting inequities embedded in the institutional structures of industrial societies [20], available energy sources [21], energy consumption rates [14,22], energy affordability [23], and trade networks for renewable energy [24]. These equity issues intersect with social and gender inequities directly or indirectly impacting energy use [25–34]. To address the evolving situation, it is important to learn from innovation failures in energy systems.

Systematic learnings from innovation success require policy innovators to assess COVID-19 practices that promote transformations that are equitable with regard to gender, structure, and sustainability [35,36]. The derived analytic themes of the study are: "gender-equitable," "structurally equitable," and "green-transformative." Systemic beliefs, values, and assumptions behind certain practices that hinder post-pandemic transformations must be unlearned while the failure to learn from innovation failures must be avoided. Renewable energy research pre-COVID-19 addressed the impetus for transitions that are socially equitable, gender-equitable, and inclusive [13–16,37–40]; green growth [12,16,41]; energy cultures [42,43]; and improved energy governance [44–52]. Coronavirus research has emphasized the need for sustainable energy transitions [53–59] as well as the need to reconsider crisis governance [60]. To unlearn the way in which scientific evidence and data are used for policy-making, other research has recommended a post-structuralist approach that creates equities [6]. Governance approaches that promote solidarity, care, and the value of the local economy are recommended for the associated transformative learnings [2,6]. However, the primary gap in the literature is how to repair structural inequities. This paper addresses that knowledge gap by adopting a policy innovation learning or unlearning approach with a transformative lens that is gender-equitable, structurally equitable, and green, and which advances innovation governance for transformative energy policy.

Insights gained from the failures in innovation governance concerning transformative energy policy should be integral components

of post-pandemic planning. Policy innovators can thereby bolster positive outcomes and prevent negative consequences [61]. This paper draws upon literature on innovation failures and practices to define "transformative governance" as the new politics of mutual solidarity and care. It is informed by experimentation, practices, technologies, beliefs, values, and assumptions that prioritize equity in terms of gender, structure, and sustainability [6,41,42,62–64]. In this context, structural inequity refers to a fragility or vulnerability to preexisting and crisis-induced inequities that are systemic, institutional, technological, social, gendered or climatic. In this context, fragility and vulnerability are concerns related to intersectionality because practices can exist between individuals, institutions, and cultures. Some practices manifest as different forms of fragility and vulnerability: pre-crisis, crisis, and post-crisis, and across socio-economic groupings [65,66]. For example, multiple fragile and vulnerable identities extracted from policy innovations in the three most populous nations in SSA—Egypt, Nigeria, and South Africa—are evident across sectors. Multiple fragile and vulnerable identities that were extracted from policy innovations of Egypt, Nigeria, and South Africa can be categorized into sub-groups according to age, gender, institution, labour, wealth, and location. To serve multiple fragile and vulnerable identities, this study combines insights on equitable transition from Raskin et al. and Muza & Thomas [15,62], which define "equitable transition" as a change in state from one paradigm to another in a manner that improves the equity of outcomes, with the gender mainstreaming approach to equitable transitions, which ensures that policies improve equity across paradigms. However, the learning process of innovative governance, needs to be simplified to decode the interconnections between transitions and transformations.

This study aimed to promote systematic learnings that are transformative from systemic failures of innovation governance for energy policy through the examination of COVID-19 practices and unlearnings of beliefs, values, and assumptions of COVID-19 policy that hinder post-pandemic transformation. The paper contributes to the current literature by promoting learning from innovation failures to foster transformative innovation. The novelty of the paper is twofold. First, the theoretical framing combines three innovation concepts: reflexivity, transformative unlearning, and intelligent failure. Learning from innovation failures is known as intelligent failure [61,67,68]. Intelligent failure capitalizes on the revised practices derived from the process of examining negative or positive outcomes, which is also known as deliberation or reflexivity [9–11]. Advanced transformation unlearns the beliefs, values, and assumptions behind policy innovations that are not transformative [35]. Transformative unlearning generates an enabling environment featuring innovation, creation, implementation, and utilization [36]. Second, although many current policy innovations are geared towards improved rebuilding, the transformative pathways of short-term and stimulus responses are fragmented. The novel approach proposed in this paper translates policy innovations into transformative pathways that are resilient to crises and climate emergencies. The analysis of policy innovations in the three largest economies in SSA, which have a combined population of about 400 million people, broadened the scope of the discussion regarding innovation governance for transformative energy policy. Additionally, the three largest economies seek renewable energy expansion and fossil fuel reduction. For innovative governance regarding transformative energy policy, the overarching research question answered is the following: How gender-equitable, structurally equitable, and/or green-transformative were COVID-19 policy innovations? The paper answers the research question by reviewing the literature to identify COVID-19 policy innovation failures; analyzing COVID-19 practices in general; assessing the policy innovations of Egypt, Nigeria, and South Africa; and developing a green transformative post-pandemic framework or plan with 10 policy learning pillars. To promote resilience and sustain post-pandemic transformation, the forms and functions of the policy learning pillars are also discussed. The paper's organization is as follows: Section 2 presents a literature review, followed by the methodology in Section 3. Section 4 presents the results of the study, while Section 5 discusses them, Section 6 concludes, and Section 7 outlines limitations and future work.

2. Literature review and theoretical framework

2.1. Innovative governance

To facilitate post-pandemic transformations, innovation governance should align with transformative strategies, capacities, and processes. Innovation governance has been applied in different fields, including living labs [69], the forest sector [70], nanotechnology [71], and resource and supplier interactions [72]. However, the assumption in these studies is that a disruption has not occurred. In the case of global disruptions like COVID-19 and climate emergencies, understanding innovation practices, beliefs, values, and learnings from past systemic failures provides the scope for transformative post-pandemic success. This paper addresses this theoretical gap by developing a post-pandemic innovative governance framework for transformative energy policy. Given the transdisciplinary post-COVID-19 agenda and the multidimensionality and intersectionality of issues addressed by transformative energy policy, a potential strategy for learning integrates a multiplicity of issues across sectors, such as food, water, health, education, critical infrastructures, and electrification. Simultaneously, innovation is itself a multifunctional facet of transformation solving cross-disciplinary issues. I selected three innovation concepts for the integrative framing: reflexivity, transformative unlearning, and intelligent failure [9–11,35,36,61,67,68]. The first innovation concept reveals that COVID-19 practices must be learned or unlearned. The second innovation concept also known as advanced transformation unlearns beliefs, values, and assumptions about policy innovations that are not transformative. The third innovation concept suggests that learnings from previous systemic failures of green transformation create innovative governance for transformative energy policy. If some practices that emerged from policy innovations mitigated COVID-19 effects, the examination of both negative and positive outcomes can inform post-pandemic transformation, and this systemic learning creates post-pandemic innovation. This paper proposes that reflexivity and transformative unlearning are the foundation upon which a transformative plan is developed using refined definitions, processes, outcomes, and dimensions.

2.1.1. Reflexivity

Trade-offs between energy practices must be anticipated at the deliberation stage. For example, trade networks in the Global South can serve as the deliberation context for COVID-19 practices. Pre-pandemic research found trade between the south to be green and low, while trade with other regional blocs is high and not green [17]. COVID-19 amplified structural fragilities and vulnerabilities within energy trade networks. For instance, selected energy practices of MLICs, (see Table 1), reflect how energy adjustments in the trade network occurred in both importing and exporting countries, such as energy consumption reductions in Brazil, renewable energy project delays in China, the introduction of billing systems and reductions in energy prices in Egypt, the reduction in imports and delayed installations in India, and the increase in investment funds in Nigeria. All these short-term adjustments aimed to mitigate the transfer of COVID-19-related burdens and the negative impacts of energy system failures on vulnerable populations. Anticipating trade-offs in energy practices ensures that the benefits of South-South green trade are protected from systemic shocks such as COVID-19 and climate emergencies.

2.1.2. Transformative unlearning

2.1.2.1. Decolonized approach. Systemic changes from advanced transformation must be learned and unlearned. In the development context, transformation also challenges existing paths, strategies, and thinking patterns. A decolonized approach that aligns with new paths, strategies, and thinking patterns must be sought. Fig. 1 illustrates three fundamental issues for analysis: the use of science and evidence in COVID-19 policy-making under conditions of uncertainty and inexperienced policy innovators, assumptions of economic growth that have shaped conventional development models, and the role of the state in the pandemic response [6]. The first fundamental challenges are the local and social actions that were most instrumental in addressing the pandemic as it unfolded. COVID-19 challenged scientific conventions. For instance, health science had relied on epidemiological modeling, and most predictions were not particularly useful for addressing the challenges of the unfolding COVID-19 situation. Nonetheless, assumptions and uncertainties in modeling complicated prediction relevance at the local level. The second fundamental challenge was that when global supply chains constrained delivery, efficiency was derived from short value chains of collective organizations and informal arrangements. These short value chains complemented economic development and trade efforts. Concurrently, the long-held assumptions of a neoliberal economy that only pursues reward, profit, and growth, were challenged by the fragility and vulnerabilities experienced as a result of COVID-19. These fragilities and vulnerabilities have shown the importance of rights and the need for social protection for those in especially precarious jobs, such as women, ethnic minorities, and migrants. Economic organization helps balance care with capital and life making with profit making. The third fundamental challenge was the management of persistent challenges concerning the analysis of problematic pre-existing, pandemic-post-pandemic related concerns regarding the participation of marginalized groups, the role of the social contract, and networks, development approaches and alliances. New politics entails the management of structural challenges: "structural governance" that creates structural equities. Policy innovators were reminded by COVID-19 of the need to reconsider the state's role in pandemic response. For example, public goods, like COVID-19 vaccines, which are developed with philanthropic investments, as well as most innovations contributing to public goods, are for private benefit. COVID-19 also demonstrated the need for pandemic responses to be localized. A key reflection point for this study is that there is a need for a decolonized local energy development perspective that considers technologies and practices that positively influence local norms and a globalized energy perspective responsive to local technological developments and practices [15,16,42,43].

Table 1
Adjustments in energy practices during COVID-19.

Practice	Country	Structural effects in selected MLICs.
Reduction in electricity consumption by 20 % [73].	Brazil	Structural fragilities and vulnerabilities from COVID-19 can be passed on to fragile and vulnerable groups. Adjustments in energy practices sought to mitigate negative effects of such transferences.
Time extension for renewable energy projects under construction equal to the lockdown period (announced on April 17, 2020 by the MRNE) [74].	China	
Energy price reductions for industrial users and tax removal on company dividends [75].	Egypt	
Decreased energy payments and introduction of PAYGO billing system for renewable energy producers; phasing out of subsidies; decreased consumer and industrial consumption by 2 GW; cost sharing, ancillary, and wheeling fees; tenders and commission on hold; short-term price reductions for industrial users; reduction or removal of the tax on company dividends (from EGP 5.50 to EGP 4.50); electricity price reduction from EGP 0.10 to EGP 0.0064 per kilowatt-hour [75].	Egypt	
80 % reduction in solar cell imports from China, production and quality-oriented challenges and wind installation disruptions [18].	India	
Postponement of Q2 2020 investment payments; CSR; COVID-19 immediate response; REA development fund valued at USD 200 million [76].	Nigeria	

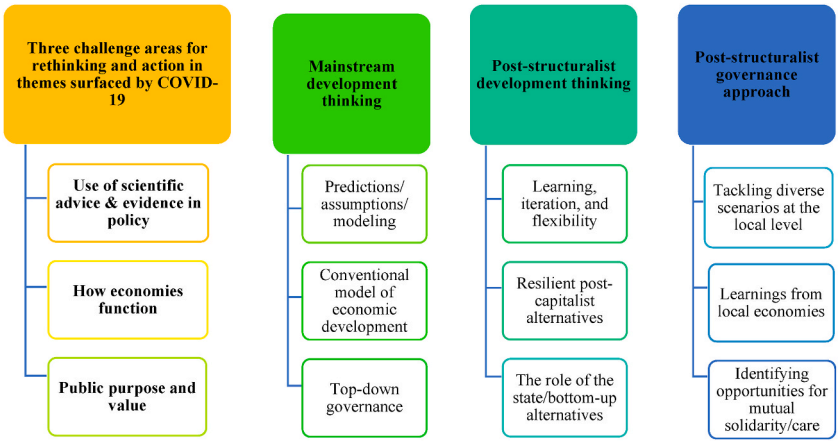


Fig. 1. Post-structuralist governance approach adapted from Ref. [6].

2.1.2.2. Post-pandemic transformations. A decolonized local energy development perspective is the backbone of post-pandemic transformation; it offers a scope for reflexive thinking on two fronts: pandemic preparedness and response, and past, present, and future development [6]. These two reflection points can help governments answer key questions, such as why the world was so fragile and vulnerable to the effects of COVID-19 and how to mitigate the damage from future threats [6]. For policy innovators asking similar questions, Daunton and Leach et al. suggest returning to policy innovation that creates just and equitable forms of globalization [6,77]. This paper follows the same arguments as those of Daunton & Leach et al.: that COVID-19 was a global threat, both as a health crisis and as a matter that intersects with socio-ecological, economic, and political crises shaping future governance [6,77]. Specifically, Leach et al. suggest that the four intersecting arguments include the following: First, COVID-19 intensified systemic fragilities, such as those regarding health and well-being, food, sustainable livelihoods, trade, ecologies, resilience, inclusive governance, resource access, and employment [6]. Second, COVID-19 vulnerabilities and impacts were experienced across geographies and social groups, demonstrating deepening poverty, intersecting inequalities, and potentially intensified authoritarianism or top-down development approaches embedded in capitalist or conventional development frameworks. Third, vulnerabilities from COVID-19 have challenged conventional development approaches that are mainstream, and capitalist; and long-run economic models promoting economic growth, market liberalization, globalization, and carbon-intensive industries; and command, and control planning. The alternatives, rooted in local solidarities and their potential to strengthen global connections, challenge global development hierarchies such as the characterization of global development by the Global North and the Global South. Fourth, policy responses can discriminate or accentuate long-standing structural inequalities, and the interplay of multiple and dynamic sources of marginalization requires that new governance is able to account for diverse livelihoods.

2.1.2.3. Transformative governance. Fig. 1 summarizes the value of a post-structuralist development approach, which can remedy the challenges that surfaced during COVID-19. This paper postulates that transformative governance is the future governance for realizing post-structuralist development. Other studies found that transformative governance reduces risks, such as those that emerged during COVID-19 (see Fig. 1), and creates development opportunities. The drivers of transformative governance are how science and evidence is used in policy-making, the role of the state, the potential for transformative governance, and the paradigms driving policy change [60]. Capacities that enable transformative governance include reflexive learning, decision-making under conditions of uncertainty, inclusion of diverse gender perspectives, and experimentation [45]. In this context, transformative governance has been applied to research on human geography disciplines, such as climate risks, adaptation to climate change, urban climate change, fire management, agriculture and food systems, resilient urban water systems, urban management, and sustainability and green economies. For a detailed discussion, see Ref. [60]. The application of transformative energy policy assists policy innovators in determining how efficiently policy innovations can tackle diverse policy issues, the potential for local capacity building, and emerging forms of mutual solidarity and care that can create structural equities.

2.1.2.4. Governance of complex energy transitions. Decolonized and transformative governance approaches assist in the management of post-pandemic energy transformations. It should be noted that energy transitions are complicated, and the intersectional agenda advanced in this paper compounds that complexity. While *reflexivity* is focused on identifying transformative practices; and *advanced transformations* on unlearning beliefs, values, and assumptions of policy innovation, and creating a conducive environment for technological adoption; all concepts together form what are known as *energy cultures* [15,16,42,43]. In this context, the ECF defines technologies as material cultures; norms as beliefs, values, and aspirations; practices as energy application or use. For example,

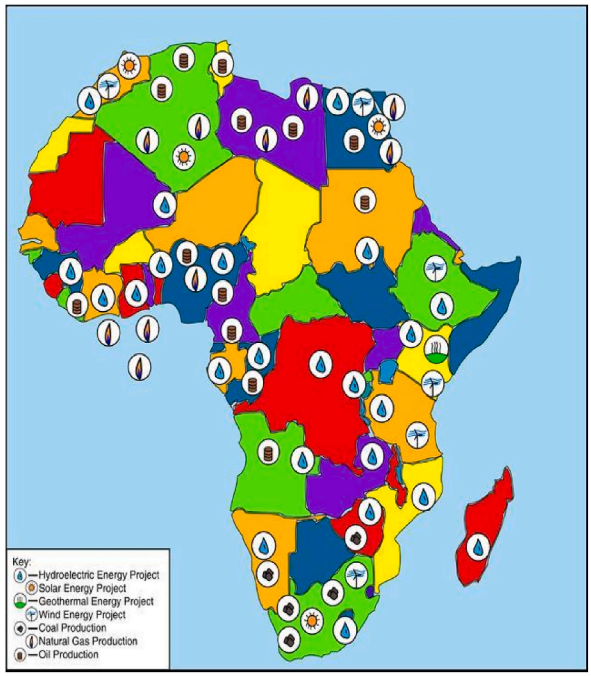


Fig. 2. Map of Africa showing fossil fuel resources and renewable energy projects across the continent [81].

changes in work culture, such as remote working practices, excluded rural population groups in Brazil that lack basic services and internet [6,7]. This paper suggests that energy cultures shape structural in(equities) and vice versa, akin to the agency versus structure debate in the social sciences, which is referred to as *genuine dialectical duality* [15,44]. Overall, the social science and energy cultures debate at the local level can complement the reflexivity of energy transitions and vice versa. The drivers of equitable global transitions are population patterns, values, technology, government structures, and economic organization [62]. These drivers shape local energy cultures and general social science research and vice versa. These drivers in turn shape the state of society and politics. Intersectional solutions with systemic impacts promote resilient and sustainable post-pandemic transformations. Simultaneously, the governance of complex energy transitions poses an intersectional dilemma regarding processes, outcomes, futures, and societies [44]. Process examples include nature of systemic changes, and how these can be improved. Outcomes include distribution, meaning, and imagination of future cultures. Low-carbon transitions manifest as futures or societies. In such an energy regime, gendered perspectives are transformative when contributing to a low-carbon transition also referred to as *the transformative pathway* [34]. The key reflection point is that energy transition improves structural equity, and transformative governance is the means to realize that transition. It is therefore imperative to identify the elements of transitional and transformative governance for transformative energy policy.

2.1.2.5. Green growth. A decolonized approach, post-pandemic transformations, transformative governance, and the governance of complex energy transitions must align with green growth standards [14]. Low-carbon green technologies are the linchpins of this alignment. A previous study that used a systematic literature review found three elements of green growth: drivers (barriers), scales or spatiality, and rationales for policy interventions [12]. The drivers (barriers) are skills, technologies, physical resources, markets, and institutions. The scales are local, regional, national, continental, and global levels. Three policy rationales for intervention are the market dynamics, the structural system, and transformational systemic failure. Market failure occurs due to underinvestment in R&D, whereas structural system failures are the result of firm incapability, and transformational systemic failure results from insufficient policy learning. Here, the paper establishes a connection between intelligent failure and green transformational system failure: learning from failure reduces green transformational system failure, and failure to learn from failure leads to transformational system failure. Another study that used a disruptive innovation approach derived transformative pathways promoting green growth at the sub-national level. The drivers (barriers) of green technology uptake are the HoH, the household's social welfare category (in that case *Ubudehe* categories), and the location of the household (either rural or urban) [16]. The key reflection point for transformative governance is that policy rationales for creating structural equities for green and just transitions should be decoded across scales.

2.1.2.6. SSA. In SSA, a local economic development approach complements the decolonized approach, post-pandemic transformations, transformative governance, the governance of complex energy transitions, and green growth standards. Irrelevant and inconsistent practices must be interrogated. For example, while most countries in sub-Sahara Africa are in the third IR, developed and emerging high-income economies are entering the fifth. Furthermore, the focus on the household setup requires new and innovative thinking because structural inequities are varied. Some populations are homeless or mobile, others are living with disabilities, chronic illnesses, or addictions, and still others consist of labor migrants, mobile pastoralists, or informal traders [6,78,79]. The literature adequately highlights the policy innovation's shortcomings in addressing the requirements of multiple fragile and vulnerable identities, as well as the severity of energy poverty [55,57]. In the literature, examples discussed include energy crises, histories, and futures of coronavirus, the politics of sustainable energy transitions, and opportunities, and outlook [53,54,56,58,59]. Prior to the COVID-19 pandemic, African energy transitions were starting to focus on energy justice [13,41]. However, there was less focus on creating structural equities. In the context of framing, a study identified a sociotechnical framing as more comprehensive than the prevailing technology and finance framing [80]. Systemic failures preventing uptake of green services and technologies in fragile and vulnerable communities must be managed. For example, continued use of pollution emitting technologies, such as coal fired equipment, even when renewable energy options are available [15]. The novelty in the current study lies in its unique approach to the framing of innovation failures.

The COVID-19 and climate change nexus must be established to accelerate post-pandemic transformations. Studies on the social anatomies of climate change and the coronavirus pandemic found the main difference to be the speed of the response. Urgency has dominated the coronavirus response, while slowness and inadequacy characterize climate responses [8]. A study of 34 SSA countries [41] found that Egypt, Ethiopia, Mauritius, Namibia, Rwanda, South Africa, and Uganda have policy frameworks with individual policies addressing energy justice. Algeria and Morocco have policy frameworks with individual policies inadequately linked to energy justice. Burkina Faso, Gambia, Mali, and Malawi have policies directly addressing recognitional or distributional justice. Zambia, Kenya, and Ghana have market-oriented energy transitions. Fig. 2 illustrates distributional justice of renewable energy, and fossil fuels. Distributional injustice is evident from concentrated production of oil and gas in North, West, and Southern Africa. The regional zones of the case countries—which are Africa's three most populous nations and largest economies—Egypt, Nigeria, and South Africa, respectively. The transformative potential of diverse energy policy frameworks, such as those in the three largest economies and this study's case countries, which collectively have about 400 million inhabitants, is a knowledge gap addressed with this study.

2.2. Intelligent failure

2.2.1. Innovative governance for transformative energy policy

Finally, a context specific local economic development approach for SSA complements the decolonized approach, post-pandemic transformations, transformative governance, the governance of complex energy transitions, and green growth standards. Policy learnings from these COVID-19 practices inform the management of transformative energy policy that promotes innovation success. Deliberation and advanced transformative unlearning are the bases of intelligent failure for innovation success. Other scholars have found that contingent learning dominates the COVID-19 era and decision-making by entrepreneurs is reactive to the emerging crisis [4,82]. However, a destabilization of current carbon-intensive regimes is necessary for energy system transformation [83]. In particular, transformative energy policy assists governments in transforming institutions of governance [84]. Nonetheless, previous energy policy analyses assumed stability in the energy system. However, in the emergency mode, policy-based learning saves public money and increases the response rate [85]. Pandemics like COVID-19 add an additional layer of complexity to existing energy regimes and institutional frameworks. The role of innovative governance is to promote change and support innovative elements of transformative energy policy.

3. Methodology

How gender-equitable, structurally equitable, and green-transformative were COVID-19 policy innovations for innovative governance of transformative energy policy? To answer this question, the study adopted a qualitative research approach and a constructivist research paradigm in decoding the practices, beliefs, values, and assumptions for innovation governance for transformative energy policy. The constructivist research paradigm is instrumental in decoding transformative material cultures, norms, and practices. In Rwanda, a previous study adopted a constructivist research paradigm, an ECF, and the grounded theory approach to explore the changes to cultural norms in productive uses for service provision, domestic purposes, and business development resulting from electrification [15]. Although Rwanda also promotes renewable energy consumption, the country's fossil fuel production is limited. In addition, the study in Rwanda focused on a pre-pandemic assessment of productive uses, while the current study focused on innovation learnings for the post-pandemic phase. The current study focused on the three largest economies in SSA that happen to be promoting renewable energy consumption and discouraging fossil fuel use. Previous studies on COVID-19 policy learnings employed other methods, such as combined ML and topic-based modeling [4]; an HI perspective; and policy learning literature [82]. As discussed in section 3.2, the current study adapted the innovation failures literature and policy innovation learnings using the RTA method. In

the current study, the analytic approach, both literary and empirical, adapted a reflexivity technique.

3.1. Justification of case countries

First, key statistics of the equitable transition (population growth, social institutions,[1] energy transitions,[2] gender equity,[3] and energy technologies, summarized in Fig. 3a and b). Egypt has a high level of economic performance at 5.5 % of GDP growth. The gender-equitable transition is advanced in South Africa[4] at an AGI value of 0.768. Nigeria has a high level of renewable energy consumption, indicated as 86.6 % of the total energy consumption. Second, policy frameworks are varied [41]. Egypt has a relatively intricate framework featuring direct components, such as net metering and auto generation. The policy includes tax reduction and integrative components, such as FiT, auctions, and enabling policies. Nigeria has direct elements, such as biofuels blending, IPP incentives, and rural electrification. South Africa has a comprehensive policy framework that combines direct components, such as solar heaters, basic energy support, and tax incentives, as well as integrative and enabling components, such as FiT auctions.

3.2. Methods and data

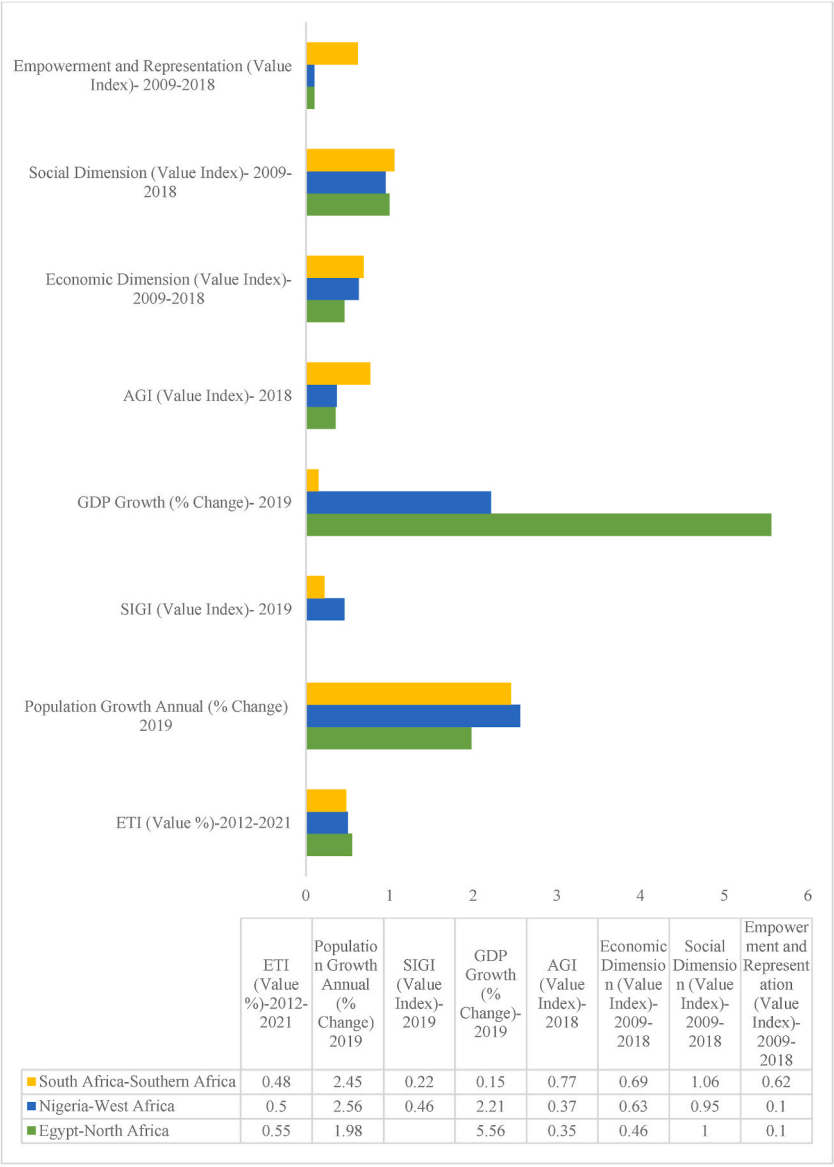
How gender-equitable, structurally equitable, and green-transformative were COVID-19 policy innovations? For the overall systemic learnings, the study method consisted of a policy toolkit with three steps summarized as the methodological flow in Fig. 3c. Each step of the policy toolkit contributed information that addressed the overarching research question and provided insights for systemic learnings in innovative governance regarding transformative energy policy. For the first policy toolkit, which is deliberation or reflexivity, I answered one sub-question: what can we learn from innovation governance failures of the transformative energy policy? To answer this, I used a systematic learning approach to identify COVID-19 practices. In general, I identified five broad practices relevant for most nations in the Global South, and those in SSA in particular. These five practices are listed here as: the decolonized approach, post-pandemic transformation, transformative governance, governance of complex energy transitions, and green growth. I generated the three analytic themes of the study which are: gender-equitable, structurally equitable, and green-transformative. Literature sources were selected based on the ability to inform the theoretical approach and the study's analytic themes. However, to reduce publication bias in the deliberation process, I consulted both scientific and non-scientific sources. Non-scientific sources included news flashes and reports from governmental and non-governmental outlets and international and local organizations. Scientific sources included published books and journal articles. This balanced consultation of sources ensured that policy learning ideas already elaborated in non-scientific sources were not repeated as novel research ideas but instead as complementary and integrative evidence. Concurrently, COVID-19 practices were mainly reported in non-scientific sources at the onset of the crisis, while scientific sources dominated the discourse at later stages of the pandemic. The study's inclusion of non-scientific sources mitigated the publi-

[1] SIGI measures gender inequity in social institutions. SIGI considers laws, social norms, and practices to capture underlying drivers of inequality with the aim of providing the data necessary for transformative policy change. The SIGI values range from 0 % for equality to 100 % for inequality [33]. Here, it represents values of the equitable transition.

[2] ETI was developed to reflect the interdependence of energy system transformation with the macroeconomic, political, regulatory, and social factors that determine a country's readiness for transition. An effective energy transition is defined as a timely transition towards a more inclusive, sustainable, affordable, and secure energy system that provides solutions to global energy-related challenges while creating value for business and society without compromising the energy triangle's balance. Countries are scored along 39 indicators on a scale of 1–100. Countries scoring the global maximum on a given indicator are assigned a score of 100 on that indicator [87]. In this paper, it represents the governance structure of an equitable transition.

[3] AGI measures progress in closing gender gaps in education and health, jobs and wages, and political participation and leadership in 51 of 54 SSA countries. The AGI value is composed of the economic, social, and empowerment and representation dimensions. The AGI ranges from 0 for inequality to 1 for equality [86]. In the current study, it represents gender equity or parity of the equitable transition.

[4] South Africa's green finance taxonomy encompasses economic activities for the transition to and realization of a green economy [160]. Fully green activities are universally accepted as green and conform to the ultimate vision of the green economy. Green transitional activities are activities that fall short of the ultimate green ambition but are progressing towards the ultimate objective, facilitating a journey from the current state to the ultimate vision of the green economy. Social taxonomy is a non-exhaustive positive list focused on social activities (some may have environmental co-benefits). Green taxonomy is a non-exhaustive list focused on environmental activities (more likely to have social co-benefits). Brown taxonomy is a non-exhaustive list of environmentally harmful or risk-exacerbating activities. Green and sustainable finance addresses national economic priorities, creates investment opportunities, and attracts local and international capital, among others. Finance classifications, or taxonomies, are an implementation tool that can enable financial markets or participants to identify and respond to investment opportunities that contribute positively to green jobs. It enables a coordinated and consistent approach for financial market participants to ensure the right foundations are in place to identify, prepare, assess, define, monitor, and disclose investments that can be considered green, climate friendly, and socially inclusive. A taxonomy assists in building consistency and credibility to support a low-carbon and climate-resilient economy that is also socially inclusive and sustainable [91]. In this paper, it represents a green economy.



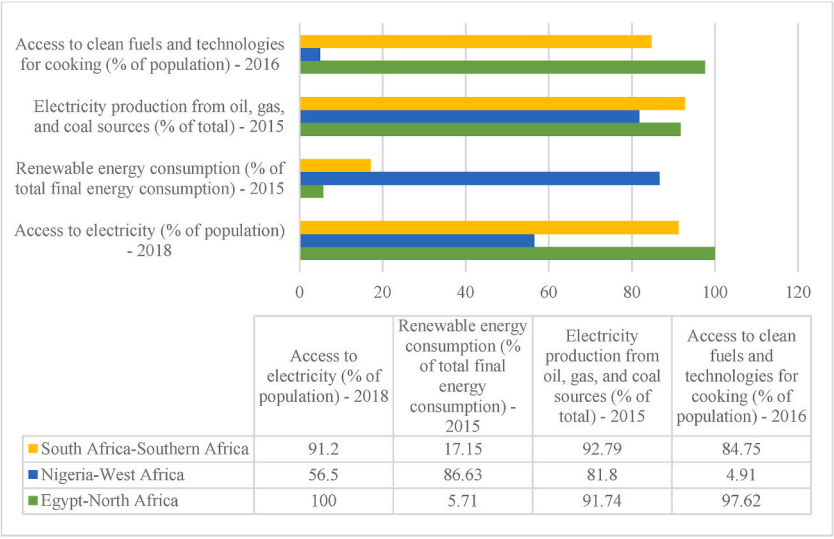
	ETI (Value %)-2012-2021	Population Growth Annual (% Change) 2019	SIGI (Value Index)-2019	GDP Growth (% Change)-2019	AGI (Value Index)-2018	Economic Dimension (Value Index)-2009-2018	Social Dimension (Value Index)-2009-2018	Empowerment and Representation (Value Index)-2009-2018
South Africa-Southern Africa	0.48	2.45	0.22	0.15	0.77	0.69	1.06	0.62
Nigeria-West Africa	0.5	2.56	0.46	2.21	0.37	0.63	0.95	0.1
Egypt-North Africa	0.55	1.98		5.56	0.35	0.46	1	0.1

Fig. 3. a. Transformative indices (derived from the equitable transition including economic and population growth, social institutions, energy transitions, and gender equity) [33,86,87], and the World Bank. **b**. Energy technologies in Egypt, Nigeria, and South Africa, The World Bank. **c**. Methodological flow and policy toolkit of the study.

cation time lag and biases resulting from consultation of only scientific sources (see COVID-19 practices illustrated in Table 1).

The second policy toolkit pertains to the transformative unlearning of beliefs, values, and assumptions performed on 58 policy innovations ($n = 58$). I created a dataset with 58 policy innovations. The 58 policy innovations are available as additional information for the study. Forty-three policy innovations (74 %) were short-term responses collected between September 2020 and October 2020 from the UNDP COVID-19 Global Gender Response Tracker[5] (see additional information of the study). Fifteen (26 %) were stimulus responses of the case countries collected from other internet sources, such as KPMG, government reports, and news flashes from the

[5] The tracker monitors policy measures enacted by governments worldwide to tackle the COVID-19 crisis. It captures two types of government responses: women's participation in COVID-19 task forces and national policy measurestaken by governments. National policy measures address issues related to women's economic and social security, including unpaid care work, the labor market, and violence against women. This paper focused on national policy measures taken by the governments of Egypt, Nigeria, and South Africa. It is important to note that the national policies implemented aim to create equity across genders. In this paper, they represent policy innovations.



	Access to electricity (% of population) - 2018	Renewable energy consumption (% of total final energy consumption) - 2015	Electricity production from oil, gas, and coal sources (% of total) - 2015	Access to clean fuels and technologies for cooking (% of population) - 2016
South Africa-Southern Africa	91.2	17.15	92.79	84.75
Nigeria-West Africa	56.5	86.63	81.8	4.91
Egypt-North Africa	100	5.71	91.74	97.62

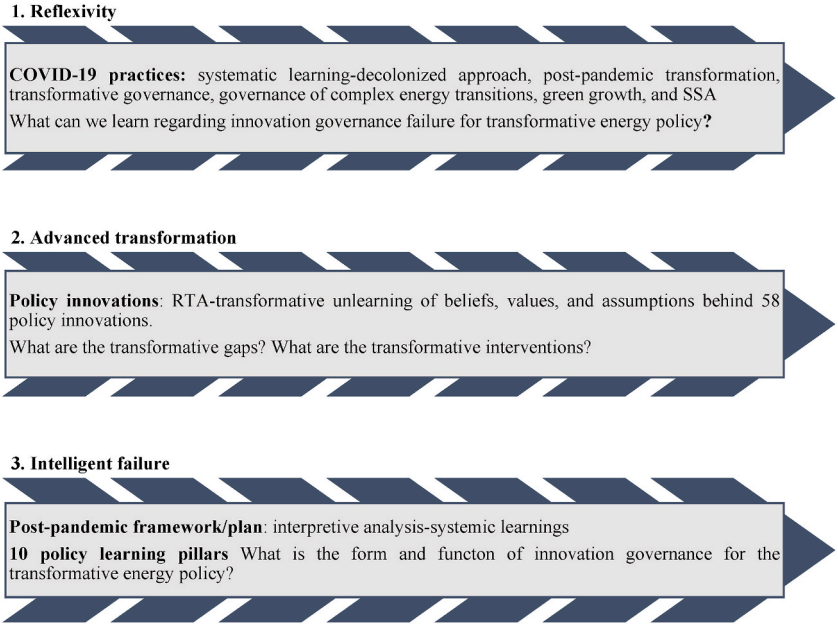
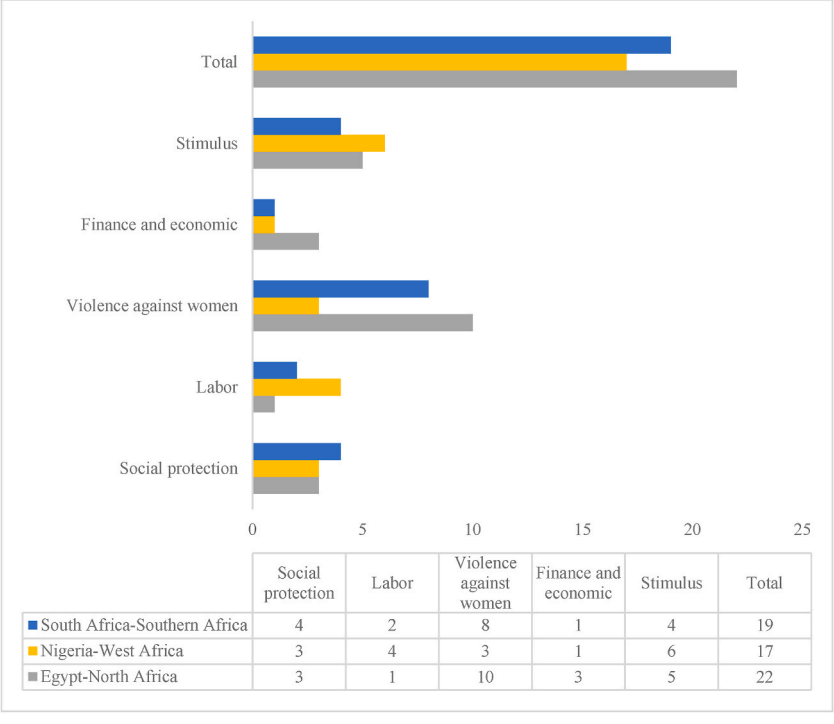


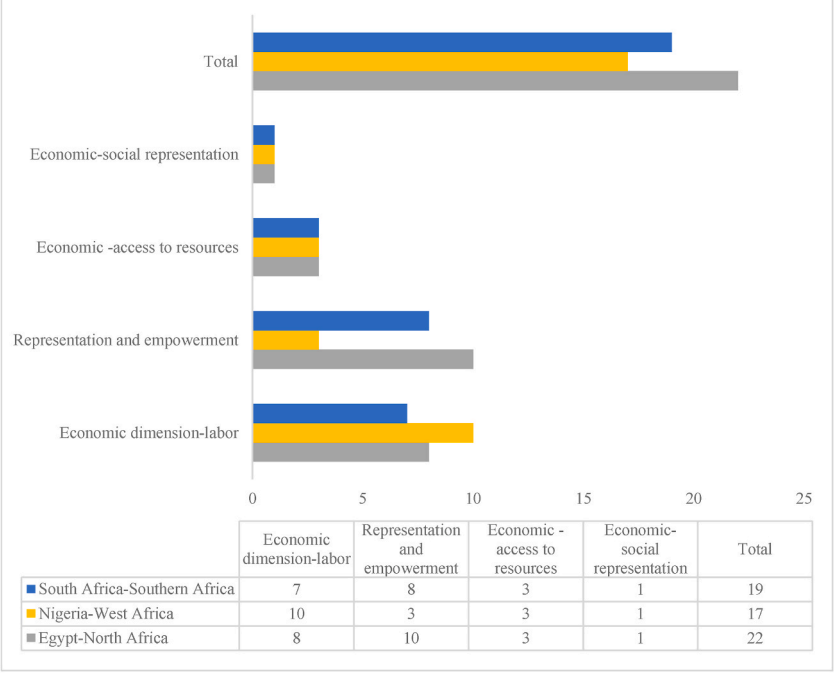
Fig. 3. (*continued*).

case countries (see additional information of the study). The sub-questions answered ask what the transformative gaps are and what are the transformative interventions? For this policy toolkit, I established a connection between the analytic themes and the coded narratives from the 58 policy innovations. I used the RTA to generate three analytic themes following deductive analysis that is theoretical and research question oriented. I considered analytic theme development to be the essence of the deliberation stage. According to Braun and Clarke [88], theoretical thematic analysis is analyst driven and seeks to theorize the socio-cultural contexts and structural conditions that enable the policy innovations that were introduced. This RTA approach is located within the artfully interpretive (Big Q) non-positivist spectrum [88–90]. Unlike positivist and experiential frameworks, non-positivist and constructionist frameworks acknowledge that researcher subjectivity is a resource for research rather than a threat to be contained [88]. I considered meaning and knowledge as contextually situated, partial, and provisional. For analytic theme development, I followed the six-phases of RTA. Initially, I generated latent codes and themes that captured the underlying ideas, patterns, and assumptions. This iterative and recursive process adapted the six-step RTA method as follows: (i) *familiarization with the data*-I assessed the dataset for its completeness, accuracy, and patterns (see additional information of the study); (ii) *generating codes*-I identified and adopted four codes which are social protection, labor, violence against women, and finance. I coded the narratives "coded narratives" under the 58 policy innovations based on their frequency under each data code in each case country; (iii) *generating themes*-I adopted the four data codes as data themes (iv) *reviewing potential themes*-I integrated and adopted an additional code stimulus as the fifth theme; (v) *defining and*

naming themes-I aligned the five data themes with the theoretical approach and overarching research question. I generated and defined the three analytic themes of the study as follows: gender-equitable; structurally equitable; and green-transformative; and (vi) *producing the report*- I used the matching technique to align coded narratives with the transformative indices illustrated in Fig. 3a. The matching transformative index for the gender-equitable transformation was the "AGI" [86], while the structural and green transformations were matched with the transformative index "green finance taxonomy" [91]. In this coded policy narrative and transformative

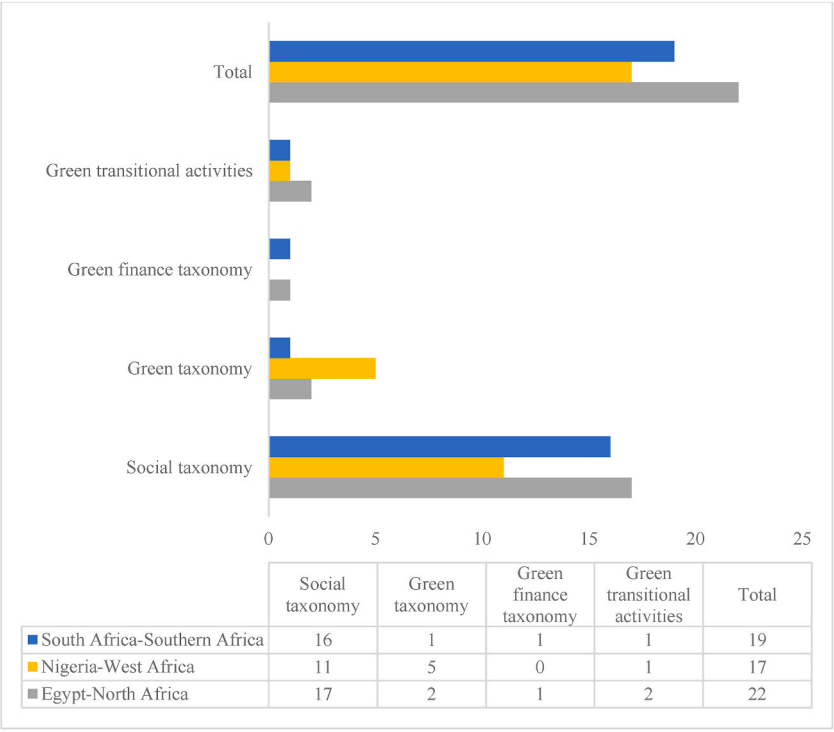


	Social protection	Labor	Violence against women	Finance and economic	Stimulus	Total
South Africa-Southern Africa	4	2	8	1	4	19
Nigeria-West Africa	3	4	3	1	6	17
Egypt-North Africa	3	1	10	3	5	22



	Economic dimension-labor	Representation and empowerment	Economic - access to resources	Economic-social representation	Total
South Africa-Southern Africa	7	8	3	1	19
Nigeria-West Africa	10	3	3	1	17
Egypt-North Africa	8	10	3	1	22

Fig. 4. **a**. 58 Policy innovations in Egypt, Nigeria, and South Africa. **b**. Transformative gender equity based on 58 policy innovations in Egypt, Nigeria, and South Africa. **c**. Transformative green finance taxonomies based on 58 policy innovations in Egypt, Nigeria, and South Africa. **d**. Transformative green technologies and services based on 58 policy innovations in Egypt, Nigeria, and South Africa.



	Social taxonomy	Green taxonomy	Green finance taxonomy	Green transitional activities	Total
South Africa-Southern Africa	16	1	1	1	19
Nigeria-West Africa	11	5	0	1	17
Egypt-North Africa	17	2	1	2	22

Fig. 4. (*continued*).

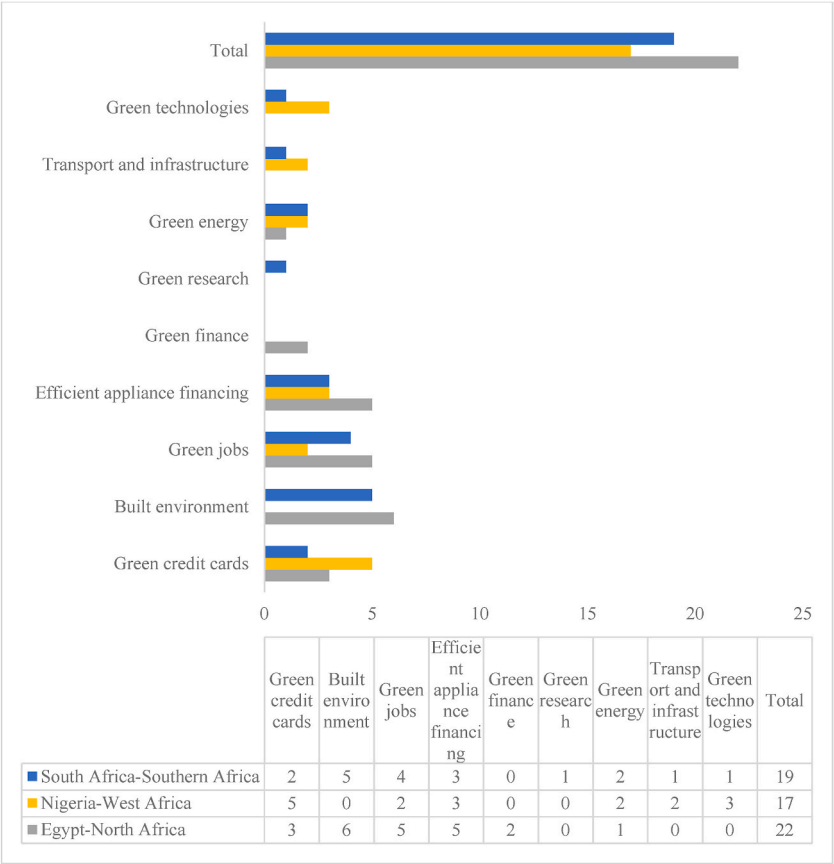
index-matching technique, selected transformative interventions closed a transformative gap. Herein, *gender transformation* refers to equitable transformation that creates opportunities for multiple fragile and vulnerable identities. *Structural transformation* refers to cross-sectoral changes stimulating economic change. *Green transformation* refers to the uptake of valuable green technologies and services. *Transformation* refers to the process of translating coded policy narratives and matching policy innovations to relevant indices.

The final policy toolkit concerns *intelligent failure,* learning from systemic innovation failures and policy innovation for innovative governance for the transformative energy policy. For this I used a systemic learning process. The learnings included what communities, researchers, practitioners, and policy innovators have identified as hindering the transformation process. The post-pandemic plan is established on the foundation of intelligent failure, drawing from innovation science and theoretical and empirical evidence global. The evidence is collected from both scientific and non-scientific sources. In the final policy toolkit, I went beyond describing data to providing a theoretical argument explaining how the outcomes addressed the research question. The detailed policy toolkit and all 58 policy innovations are available as a separate publication (see the additional information section).

4. Results

4.1. 58 Policy innovations

As discussed in phases 1–4 of the six-step RTA method (see section 3.2), I allocated coded policy narratives across five data themes; stimulus, finance and economic, violence against women, labor, and social protection. Finance and economic, violence against women, labor, and social protection policy innovations were short-term oriented. As a result, nations introduced stimulus responses that are medium-term oriented. Fig. 4a summarizes the 58 policy innovations implemented in the three case countries. With these 58 policy innovations, policy innovators were responding to the short-term and medium-term needs of multiple fragile and vulnerable identities. Table 2 illustrates that 22 multiple fragile and vulnerable identities were reached with the 58 policy innovations. The 22 multiple fragile and vulnerable identities were categorized into seven groups according to age, gender, institution, labor, location, wealth, and other fragility and vulnerability. Seventeen short-term responses and five stimulus responses ($n = 22$) were implemented in Egypt, eleven short-term responses and six stimulus responses ($n = 17$) were implemented in Nigeria, and fifteen short-term responses and four stimulus responses ($n = 19$) were implemented in South Africa. Because policy innovators had adjusted existing energy practices using different mechanisms (see Table 1), COVID-19 policy innovations needed to compensate for cross-sectoral welfare losses by protecting multiple fragile and vulnerable identities and reducing trade-offs. To rephrase, policy innovators reduced risk and mitigated the negative effects of the disruption. Table 2 illustrates that beyond gender-responsiveness, the multiple fragilities and vulnerabilities can take other forms. For example, the 58 policy innovations can be categorized into other fragilities and vulnerabilities; age,



	Green credit cards	Built environment	Green jobs	Efficient appliance financing	Green finance	Green research	Green energy	Transport and infrastructure	Green technologies	Total
South Africa-Southern Africa	2	5	4	3	0	1	2	1	1	19
Nigeria-West Africa	5	0	2	3	0	0	2	2	3	17
Egypt-North Africa	3	6	5	5	2	0	1	0	0	22

Fig. 4. (*continued*).

Table 2
Multiple fragile and vulnerable identities by sub-divisionbenefiting from 58 policy innovations.

Age	Gender	Institution	Labor	Location	Wealth	Other Fragility and Vulnerability
Elderly. Young people. Young graduates.	Female headed households. Women.	MSMEs. School children. Petty traders. Farmers. Distressed and disabled farmers. Mothers. Tenants.	Informal workers. Unemployed people.	Rural women. Displaced persons. Distressed and displaced farmers.	Chronic and transient poor. Poorer and vulnerable households.	Orphans. Disabled. Vulnerable groups.

institution, labor, wealth, among others (see Table 2). Within sub-divisions, needs are gendered. This finding supports the notion that gendered policy innovations (using subcategories such as female-headed households and women in Table 2) may exclude other gendered fragilities and vulnerabilities within sub-divisions (illustrated as age, institution, labor, location, wealth, and other fragility and vulnerability in Table 2). The results demonstrate that policy innovations were gender inequitable in their short and medium-term emergency and gender-responsive mode. Other transformations needed for the policy innovations are equitable structure and green.

4.2. Transformative unlearning

4.2.1. Gender-based transformative unlearning

As illustrated in phase 5 of the six-step RTA method (see section 3.2) and literature and theoretical framework (see section 2), I identified the first transformative intervention as gender-equitable. The matching transformative index is AGI. Gender transformation unlearns emergency gender-sensitive responses, beliefs, values, and assumptions to inform post-pandemic, gender-equitable transformations. Results of the coded policy narrative and transformative gender index or the AGI matching technique demonstrated that in

the long-term multiple fragilities and vulnerabilities would have benefited from transformative innovations. Such transformative innovations encompassed combinations of transformative mechanisms, such as socially inclusive economic transformations, resource access for economic transformations, representation and empowerment in transformations, and labor-representative transformations (see Fig. 4b). A transformative, gender-equitable energy policy supports transformative sustainability, leadership for green jobs, finance, and MSMEs. In the translation of policy innovations, gender-equitable transformative pathways are derived from gender-responsive unlearning using AGI as the transformative index. The derived gender-equitable transformative pathways promote innovative governance for transformative energy policy.

4.2.2. Structurally transformative unlearning

Structurally equitable is the second analytic theme I identified in section 2 (literature and theoretical framework) and section 3.2 (phase 5 of the six-step RTA method). The transformative index is green finance taxonomy. In the long-term, multiple fragilities and vulnerabilities presented in Table 2 could have benefited from structurally equitable interventions. In the transitional mode, a structurally equitable transformative energy policy creates socio-economic equities that are green and financially transformative. Fig. 4c exhibits how structurally transformative innovations combine green transitional activities and green taxonomies that create financial, green, and social equities. Structurally equitable transformative pathways are derived from structurally transformative unlearning that adopts green finance taxonomy as the transformative index in the translation of policy innovations. Structurally equitable transformative pathways promote innovative governance for transformative energy policy. The structurally equitable transformative pathways interconnect with gender-transformative pathways (Section 4.2.1), multiple fragile and vulnerable identities (Table 2), and COVID-19 policy innovations (Section 4.1). In the transition mode, structural transformation is also gender-transformative.

4.2.3. Green transformative unlearning

I identified the third analytic theme as green-transformative in both section 2 (literature and theoretical framework) and section 3.2 (phase 5 of the six-step RTA method). The matching transformative index is green finance taxonomy. The transformative pathway that begins with gender-equitable transformations, is complemented by structural equity and environmentally sustainable (green) equitable transformations. For example, gendered multiple fragile, and vulnerable identities thrive in the enabling environment that promotes economic growth and uptake of green technologies. To achieve that, the green transformation unlearned the gender-response beliefs, values, and assumptions using the green finance taxonomy transformative index. Fig. 4d visualizes nine categories of green technologies and services that can support a low-carbon transition. The most frequently observed green technologies and services are appliance financing, green jobs, the built environment, and green credit cards. The least frequently observed are green research and finance, while green technologies, transport, and infrastructure and green energy are also less common. A green equitable and transformative energy policy supports the management of all green technological pathways. It includes derived gender-transformative and structurally transformative pathways (as depicted in Fig. 4a, b, and 4c). Transformative pathways that are green and equitable are derived from green transformative unlearning of gender-sensitive responses with the green finance taxonomy transformative index. Green and equitable transformative pathways not only foster innovative governance for transformative energy policy but also prioritize gender equity and structural equity.

4.3. Green stimulus

4.3.1. Egypt

I illustrated that stimulus responses in Egypt promote economy recovery in Phase 5 of the six-step RTA method (see section 3.2) and transformative unlearning (see section 4.2). Results from the 17 short-term policy innovations implemented in Egypt in response to the COVID-19 pandemic support the need for stimulus responses (see section 4.1). Five stimulus responses close the short-term responsive gap created by the 17 policy innovations. The transformative stimulus for Egypt was innovative financial partnerships. Innovative financial partnerships should have instrumental and transitional power regarding green transformative pathways. A partnership approach inclusive of local and international actors is driving Egypt's green stimulus, which is focused on sustainable energy and green finance [92,93]. State and non-state actors are key players in this partnership. Non-state actors include the EBRD, the EU, and the GCF who provide green finance for the implementation of GVC and GEFF programs. In GVCs, the green transformative pathway (visualized in Fig. 4d), enhances program targeting, financial access, and the acquisition of green technologies and services for multiple vulnerable identities across age, gender, institution, labor, location, and other fragilities and vulnerabilities (see Table 1). The derived green transformative pathway, which is also gender and structurally equitable, can be integrated into mainstream policies through a green stimulus package that promotes gender equity, social inclusiveness, green technologies, and services uptake. The alignment of these derived pathways can also be extended to new projects included in the stimulus packages. The projects encompass a range of initiatives, including:

1. Water- and resource-efficient solutions, with a total investment of EUR 220 million.
2. GCF concessional co-financing, valued at EUR 30 million.
3. Technical assistance valued at USD 24 million.
4. A GVC program aimed at MSME funding for advanced technologies, climate change mitigation, and adaptation, valued at EUR 70 million.

5. GEFF green finance initiatives aimed at targeting MSMEs across various sectors such as agriculture, construction, commerce, and manufacturing, valued at EUR 150 million.

Derived transformative pathways can also be mainstreamed in state programs, such as the 41 environmentally friendly projects listed by the government. Of those, five projects are to be financed by two-thirds of the proceeds from the sale of bonds. The five projects concern the construction of a monorail serving the new capital, 6th of October city; a desalination plant in El Dabaa; and wastewater treatment plants in east Alexandria and Arab El Madabegh in Assiat Governorate. The state finance and SGFF green bond, valued at USD 750 million, was issued in September 2020. The financed programs include sea water desalination plants that could provide 6.4 million cbm/d of water, and investment, valued at EGP 134.2 billion, until 2050. The plan spans six 5-year phases that include:

1. EGP 45 billion in state funding to build 47 desalination plants by 2025.
2. The new monorail project, covering approximately 54 km between the new capital and Nasr City, expected to be completed by 2022 and valued at USD 45 billion.
3. Another rail project spanning 42 km from 6th of October city to Gameat El Dowal Street, scheduled for completion in 2023.

4.3.2. Nigeria

In phase 5 of the six-step RTA method (see section 3.2) and transformative unlearning (see section 4.2), I illustrated that stimulus responses in Nigeria promote economy recovery. Results from the 11 policy innovations implemented in Nigeria in response to the COVID-19 pandemic support the need for these stimulus responses (see section 4.1). Six stimulus responses close the gap in short-term response that the 11 policy innovations represent. The transformative intervention for Nigeria was government interventions. Transformative government initiatives with an instrumental and transitional impact have the potential to transform the derived green transformative pathways. The state is overseeing Nigeria's stimulus package, which has adopted a sustainability approach [94,95]. As of July 2020, Nigeria's stimulus package was valued at USD 5.9 billion (NGN 23 trillion). It is evident that the stimulus package has been mainstreamed in the ESP and MTEF (2021–2023). To maximize sustainability, the derived transformative pathways (see Fig. 4a, b, 4c, and 4d) can also be mainstreamed in the stimulus package, which has six elements, as summarized in Fig. 6. First, five million off-grid households, equivalent to about 25 million individual Nigerians, are expected to benefit from green spending for renewable energy capacity through SHSs valued at USD 620 million. This energy stimulus incentivizes private solar installations and diversifies the economy through in-country manufacturing of solar infrastructure. As 10 % of the stimulus package is allocated to the energy stimulus, Nigeria has one of the largest renewable energy interventions from an MLICs perspective. Second, a subsidy removal can save the government at least USD 2 billion each year. Third, about 61 % of the survival fund targets women, who make up 41 % of micro businesses under the National MSMEs Survival Fund. Fourth, the agriculture program under the APP seeks to increase acreage and create jobs for youth. Climate-smart agriculture strategies for adaptation and emission reduction are reflected in the country's climate pledge for 2016–2020. Fifth, the NDCs target 20 % reduction of emissions by 2030. The NAP Framework reports a similar goal. However, the ESP and the MTEF focus on investments in public works, such as roads, natural gas, fossil fuels, and clean energy. Lastly, a 1 % injection of GDP is allocated to stimulate economic growth and diversification, thereby contributing to social protection and job retention.

4.3.3. South Africa

I illustrated that stimulus responses in South Africa promote economy recovery in transformative unlearning (section 4.2) and phase 5 of the six-step RTA method (see section 3.2). Results from the 15 policy innovations implemented in South Africa in response to the COVID-19 pandemic support the need for 4 stimulus responses (see section 4.1). Stimulus responses close the short-term response gap that the 15 policy innovations represent. The transformative intervention for South Africa was sustainable energy and green finance. The transformative intervention with instrumental and transitional power has the potential to transform the derived green transformative pathways. In support of the transformative intervention, a diverse array of stakeholders is involved, encompassing both public and private sectors, academia, local, and international entities, and labor organizations. Together they are leading South Africa's stimulus package, known as *green finance taxonomy* [91,96]. The stimulus package has been seamlessly integrated into the green finance taxonomy, which in turn is an integral part of our broader sustainable development strategy, as summarized in Fig. 7. By adopting a sustainability approach, South Africa aims to accelerate job creation, enhance liquidity, promote competitiveness, facilitate the transition to a more resilient economy, and society, drive economic recovery, and improve social resilience. To boost sustainability, derived pathways can also be mainstreamed in the stimulus package (see Fig. 4a, b, 4c, and 4d). International funding, valued at ZAR 1.8 trillion, is being directed toward securing cost-effective financing, with the primary goal of generating 500,000 direct jobs. Additionally, a substantial allocation of USD 83 billion in cheaper funding has been earmarked to mitigate risks associated with the transition [91].

5. Discussion

5.1. Intelligent failure: the rationale

Learnings from the theoretical approach and analytic themes supported the need for gender-equitable, structurally equitable, and green-transformative interventions (section 2). For that, intelligent failure was discussed as the systemic learning process. Learnings

from innovations that fail assisted with the description of a post-pandemic plan. An interpretive analysis was performed in order to identify the underlying patterns, structures, and assumptions, regarding the three analytic themes of the study in the final phase of the six-step RTA method (see section 3.2). Results indicate that the policy innovations implemented in the three case countries were inequitable in terms of gender, structure, and sustainability (see section 4). As gender, structural, and green-transformative pathways are intertwined (see Fig. 4a, b, 4c, and 4d), the study presents both rationales for green transformational failure and innovative governance for transformative energy policy. For the promotion of innovation governance for transformative energy policy, results indicated that 58 policy innovations that were gender-responsive during COVID-19 must be transformed into gender-equitable, structurally equitable, and green-transformative pathways.

Concurrently, transformative pathways and stimulus packages must promote green growth by unlearning established pre-pandemic and pandemic practices, beliefs, values, and assumptions. This process is essential for shaping policy frameworks that address structural issues and promote a resilient green market while addressing potential system failures. For example, energy practices that were implemented during COVID-19 must be readjusted to pre-pandemic levels (see adjustments presented in Table 1). In Egypt, the goal of a renewable energy transition had been on the pre-pandemic policy agenda [97], but COVID-19 disrupted the transition processes. In addition, other transition concerns had been reported prior to the COVID-19 pandemic, including shortages in basic service delivery, such as general health, and gendered health; transportation; financial access; information-related; business support; and social norms that promote profitable, and strategic participation in the GVCs [98]. In Nigeria, despite the mainstreaming of group needs into the NGP,[6] the presence of entrepreneurship limitations and inadequate funding has led to the exclusion and disparities among vulnerable groups, such as women's and children's rights protection under Outcome 2 and the overall poverty index under Outcome 3 [99]. South Africa estimated between 4 % and 10 % COVID-19 losses, including 1 million jobs and 1,600 businesses [100]. Additional persistent challenges include natural resource depletion, the gap between the rich and poor, increasing trade-offs between ecosystem protection and social development, and energy poverty in male-headed households [91]. While the nation has adopted a basic services approach, it's evident that firms' capability and agency remain lacking among vulnerable groups [91]. Furthermore, the focus of service delivery in rural shelters has primarily centered on treatment rather than preventive measures [30]. However, South Africa has managed to successfully integrate the majority of these new interventions into sustainable development efforts, which can be considered a strength of its green finance taxonomy.

5.2. Intelligent failure: learning from innovation governance failure

Intelligent failure informs sustainable options for gender-equitable, structurally equitable, and green-transformative pathways. As summarized in Fig. 8, policy rationales for systemic failures are crucial for green systemic success that promotes learning from innovation governance failure. Policy rationales include investments in R&D, such as research taxes and subsidies in response to market failure, the ability to respond to new generic technologies and changes in market demand for structural system failure, and the ability to monitor, anticipate, and adjust transformational change for transformational system failure [12]. It is vital to learn from the past, present, and anticipated failures. Overall, the protection of workers' rights in oil- and coal-based industries or businesses remains a priority in all three case countries. COVID-19 research also demonstrated that social protection of vulnerable workers is a global priority [101–105]. In general, social institutions have performed better in South Africa than in Nigeria, while statistics for Egypt are absent (see Fig. 3a for the SIGI value). At the regional level, six challenges outlined by Agenda 2063 concern multiple partnerships, commodity exports, manufacturing through regional trade, intra-African trade, renewable energy, and digitization [106]. The application of intelligent failure to learn from green system failure promotes success.

5.3. Intelligent failure: post-pandemic plan for transformative energy policy

Intelligent failure must inform the development of a sustainable plan for gender-equitable, structurally equitable, and green-transformative pathways of innovative governance. Learnings from innovation failures are critical in order to guide, define, monitor, evaluate, and promote post-pandemic transformative pathways. For that reason, the 10 policy learning pillars developed in this paper are referred to as The Muza 10-PLP_4IG_4TEP. Deliberation of innovation governance and transformative energy policy was the basis for the transformative unlearning and systemic learning crucial to the integration of policy learning pillars. The deliberation that followed the reflexivity process focused on key practices, such as a decolonized approach, transformative governance, post-pandemic transformations, governance of complex energy transitions, and green growth. The derived science and evidence informed innovative governance for transformative energy policy (see Section 2). Policy professionals needed to accelerate evidence generation and learning for multiple objectives relating to intelligent failure including the following: First, utilization of digitization opportunities and uncertainty reduction in the measurement of complex change for broader audiences [85]. Second, the consideration of scales was pertinent for policy learning. The form and function of the post-pandemic plan, which has been dubbed the "dual nature" of the framework, must be discussed. As the emerging post-pandemic innovation governance for transformative energy policy involves the integration of both bottom-up and top-down approaches, it is essential to consistently and effectively manage this dual framework.

[6] Sectors identified for mainstreaming gender equity include agriculture/rural development; environment and natural resources; gender and HIV/AIDs; health and reproductive health/rights; education or training; labor or employment; women's political participation and engendered governance, including gender and conflict management; and supporting institutional development, including identifying new partnerships with men's organizations, faith based organizations, and transitional institutions [161].

In addition, this duality supports the systemic learning required for innovative governance. The 10 policy learning pillars of the post-pandemic transformation include gendered and transformative perspectives that align locally, nationally, regionally, and globally; the transformative turning point versus the transformative tipping point; transformative socio-ecological justice framing at the local level; transformative innovation administration; transformative AEU; transformative green technologies specific to the location and context; transformative business cases or value propositions; transformative alternatives to mainstream perspectives; transformative localization and reengagement in global supply chains; and transformative new politics.

First, it is critical to note that, in practice, the aligning gender-equitable, structurally equitable, and green-transformative pathways at the sub-national, national, regional, and global levels may be challenging due to varying perspectives on gender, structure, and green perspectives. Global and local narratives need alignment [15]. Imminent trade-offs between scales, sectors, partnerships, economies, and regions must be managed. For example, given that policy rationales for green market, structural system, and transformational system failure are multi-scale, "vertical alignment" can establish the link between local, regional, and global perspectives. Concurrently, the "innovation-pathways" that stem from the identified policy innovations and transformative approaches in the case countries exhibit a cross-sectoral nature (see Section 4). At the regional level, AfDB is creating structural equities through the AFAWAZ program, which provides business financing to women in MSMEs. The intelligent failure includes different partnerships at the national, regional, and global levels; and financial instruments that introduce additional layers for transformation. Policy innovators interested in transformative finance must integrate different financial perspectives. Concurrently, stimulus packages in Nigeria and Egypt are driven by global financial partners (see Figs. 5 and 7). Nonetheless, at the global level, programs such as the 2X Challenge and Gender Finance Collaborative Principles use a gendered lens to monitor initiatives—such as financial access, sustainable energy, and digitization—in key sectors, such as health, agriculture, and MSMEs. In addition to collaborative principles, cooperation approaches are useful in co-opting interactions, technology enablers, and ICTs [107].

As regional transformation complements the post-pandemic transformation, intelligent failure becomes essential for the identification of six transitional issues under Agenda 2030 [106]. The initial challenge involves redefining economic management by leveraging new cross-sectoral and multi-stakeholder platforms that establish connections among businesses, governments, international partners, and civil society. The second issue is upholding regional targets for the reduction of commodity exports in locations where smallholder farmers and small-scale miners are concentrated. The third issue pertains to the promotion of manufacturing through regional activities such as AfCFTA, where a significant number of women tend to be predominantly engaged at the lower tiers of value chains. The fourth issue revolves around maximizing intra-African trade, which holds greater investment potential compared to trade with the global market. An integral aspect of this challenge is the integration of women-led businesses into AfCFTA. The fifth issue centers on promoting a smart recovery strategy characterized by an emphasis on education in digital technologies and the integration of informal businesses into the formal sector. It is crucial to address the limited access to these opportunities among various demographic groups. The sixth issue involves accelerating the transition to renewable energy. This transition tends to progress at a sluggish pace and has relatively limited reach, as evidenced by the statistics on energy projects, technologies, GDP, and population growth in case countries (see Figs. 2 and 3b). Nonetheless, during COVID-19, adjustments in renewable energy trade networks disrupted supply at a time when renewable energy was deemed more profitable than fossil fuel, oil, natural gas, and coal. In sum, the alignment function of the first policy learning pillar is to monitor, account, create, and govern structural equities. It aligns decolonized perspectives; equitable paradigms, regimes, and revolutions; and the resilience required for responses to future pandemics (see Section 2). This alignment (see Pillar 1) could be strengthened by alliances or acquisitions that create structural equities. It includes the efficient absorption of actors that accompanies positioning, embeddedness, and learning outcomes within and outside partnerships and other organizations, such as inside ties, clique-spanning ties, and outside ties [108–112]. The transformative plan's first pillar, known as the *gendered and transformative perspectives that align locally, nationally, regionally, and globally* pillar, is denoted by Pillar 1 in Fig. 9.

Second, efficient management of systemic failures by all stakeholders creates the momentum for post-pandemic transformation enriched by transitional and transformative learning across responses: pre-crisis, emergency, stimulus, and post-crisis. A post-pandemic takeoff is accelerated when it includes both income and non-income drivers. Nonetheless, non-income drivers are often neglected. Non-income drivers for inclusion are financial decision-making, institutional support, and accessible and affordable finance [113]. Leach et al. recommend that determinant multiple-criteria analyses for success are beyond growth, and profit [6]. Some important elements for consideration are equity; resilience; sustainability; and value in the economy of essential workers; of local production and markets; of networks of sharing and low-carbon sourcing of goods [6]. Policy innovators can create equitable energy transitions by establishing entry points in energy governance for women-led governance and planning [39]. Green energy technologies

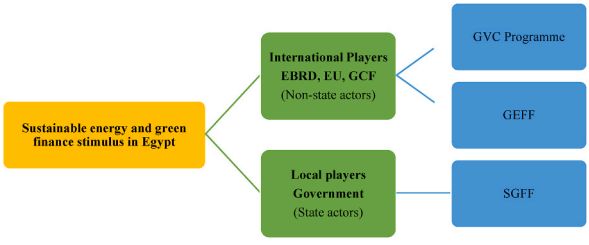


Fig. 5. Sustainable energy and green finance stimulus for Egypt adapted from grey literature [92,93].

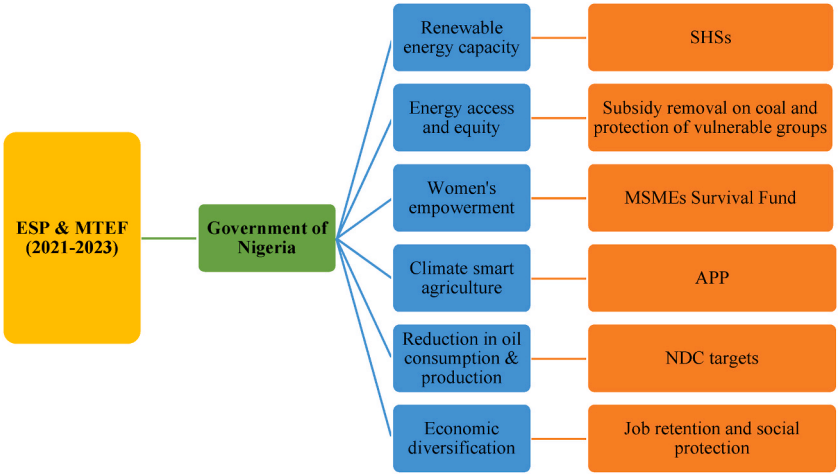


Fig. 6. ESP & MTEF of Nigeria, adapted from grey literature [94,95].

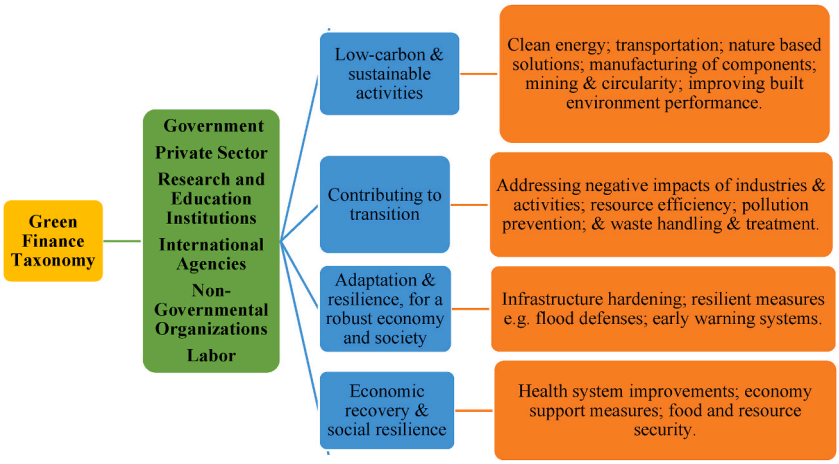


Fig. 7. Green finance taxonomy for South Africa, adapted from Refs. [91,96].

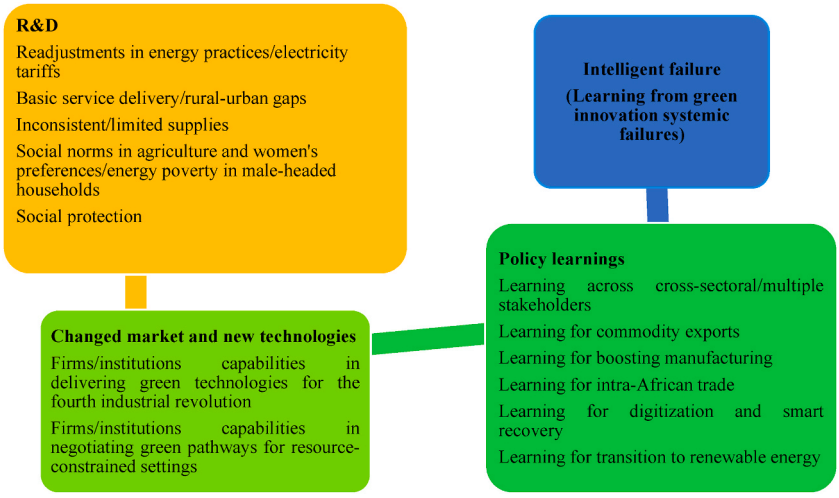


Fig. 8. Learning from green innovation failure.

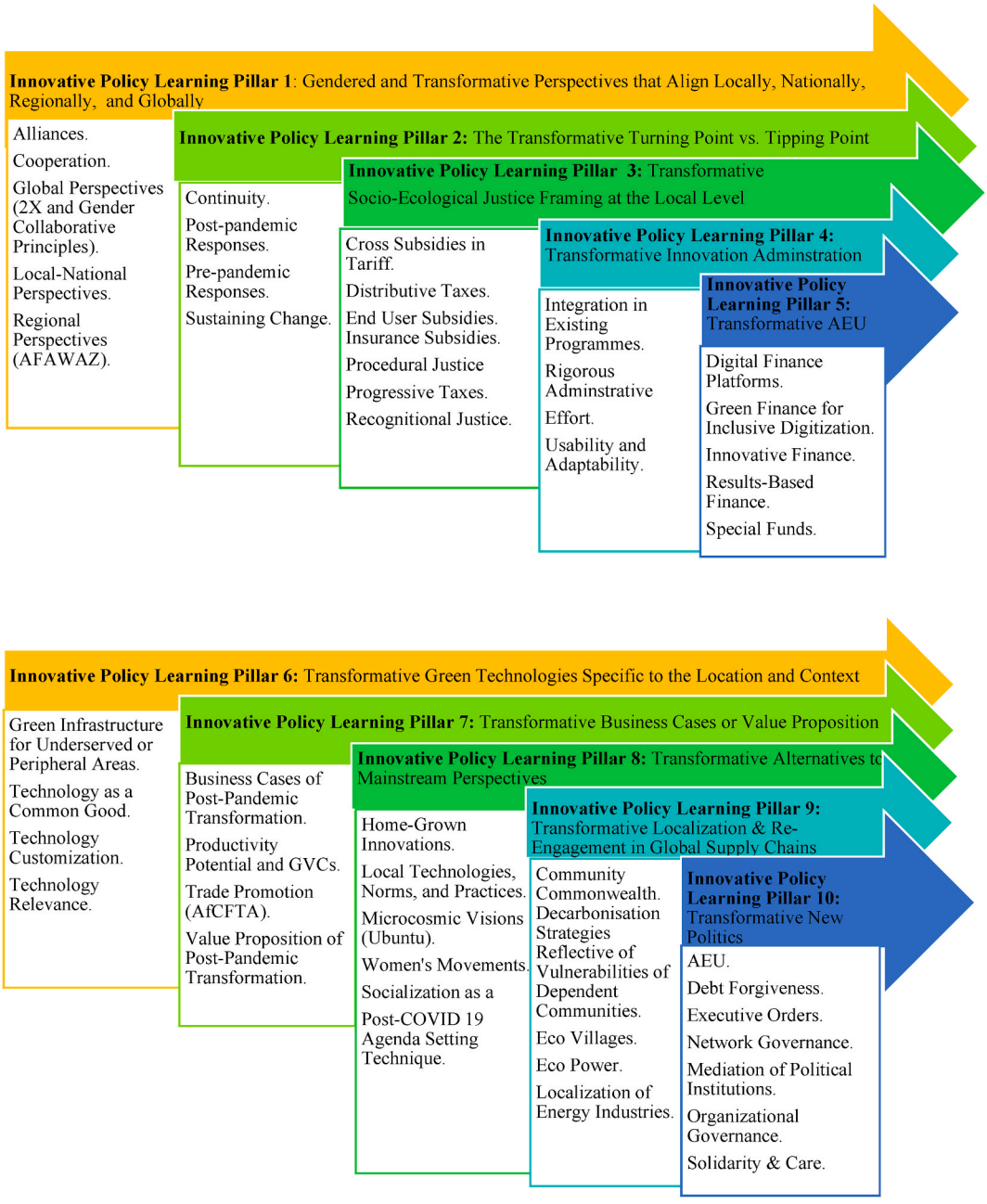


Fig. 9. The Muza 10-PLP$_4$IG$_4$TEP, based on intelligent failure.

and services across the pandemic phases for which women are WTP and ATP must be established [14,114] and post-pandemic implications for the demand of those energy services. Involvement of women as agents of change in green transformations, given their roles in local energy production [34]. Families and kin networks influence energy behaviors differently across fragile and vulnerable identities in the Global North and South [39]. A transformative energy policy suitable for fragile and vulnerable identities in the Global South is to be established with transformed processes, systems, and organizations or comprehensive package of support, including capacity building in technology, business skills, and leadership; marketing, promotion, and distribution; access to finance; one-to-one mentoring [37]; and the role of women in energy efficiency [40]. Fig. 4c and d presents complementary green sectors, technologies, and energy services. However, the decentralization expected in green technology manufacturing also involves knowledge transfer and teams of professionals accompanying the decentralization of processes. Further studies could explore the kind of shifts required at the local level to accommodate GDTs [115] or the alignment expected across transformative pathways (see Fig. 4a, b, 4c, and 4d). Because management for change and continuity in the energy transition is transformative (denoted by "ETI" in Fig. 3a), this pillar represents

the use of science and evidence for policy-making. Its function is the mitigation of transitional failure using innovative localized strategies. The second pillar referred to as *the transformative "turning point" versus the transformative "tipping point,"* denoted by Pillar 2 in Fig. 9.

Third, in the face of a multitude of social framings that can accommodate different agendas and regimes, the institutionalized post-pandemic mechanisms can play a pivotal role in mitigating the complexities associated with transformation. For instance, a local socio-ecological framing can create structural equities, particularly when these policies are both progressive and distributive. Recent research demonstrated that despite payment mechanisms, such as the PAYGO business model (see Table 1 for a similar strategy adopted in Egypt), the actual costs of off-grid solar products, SHSs, and irrigation equipment, remain unaffordable for the poorest households. For example, the introduction of innovative solar subsidies with insurance, consumer or end-user subsidies, and cross subsidies in the tariff. Togo's CIZO Cheque provides a monthly subsidy of XOF 2,000 (USD 4.00) to households with SHSs procured from authorized providers over a 3-year period [116]. Similarly, Rwanda, in partnership with ENDEV, piloted an end user subsidy program in 2019 to improve electricity access for 31,000 households that could not afford to buy them at the standard market price [117]. The SHSs program proposed in Nigeria (see Fig. 6) may explore similar sets of subsidies. However, recognitional, distributive, and procedural components are known to distort the market, and targeted policy innovations and mechanisms can inform the post-pandemic transformation. For example, COVID-19 interventions could have been designed and targeted via existing energy assistance programs complemented by rigorous administrative efforts and consistent funding that includes special funds and cross subsidies in the tariff [114]. In the post-pandemic transformation, avenues for rigorous administrative effort exist for policy innovations created through gendered, structural, and green transformative pathways (see Fig. 4a, b, 4c, and 4d) and as well as stimulus financing (see Figs. 5–7), co-opted into existing resilience building programs and policies. The function of the third pillar is the operationalization of social protection and energy justice mechanisms in the management of complex energy transitions for green growth. The pillar responds to vulnerabilities emanating from histories of marginalization, black and ethnic minorities and trust and inclusivity as a social contract [6]. It is the *transformative socio-ecological justice framing at the local level* pillar, or Pillar 3 in Fig. 9 in the transformative plan.

Fourth, digital capabilities that increase competitiveness for gender-equitable, structurally equitable, and green-transformative innovations, must be explicitly addressed. Examples of modern digital and AI capabilities include a transformative road map, talent, new operating model, distributed technology environments, data, user adoption mechanisms, and enterprise scaling [118]. However, while AI has transformative potential, it has also disrupted financing, healthcare, manufacturing, retailing, supply chains, logistics, and utilities [119]. Simultaneously, internet usage has created opportunities for problem-solving, proactive study, information gathering, and awareness-raising, both locally and globally [118]. Other documented disruptions include physical activities that require human contact, thinking, concentration, and memory skills, as well as those that may promote isolation, depression, and laziness [120]. For example, during the pandemic, accessible online platforms for communication, transaction, and education mitigated the negative effects of lockdown policies that restricted travel. However, gender, structural, cultural, and social norms are policy rationales for R&D that promote women's access to useful and green technological hardware and software and their inclusion in digital and financial services. Additionally, investments in R&D and other creative industries that promote the design of innovative hardware and software can reduce overdependence on digitization or its overuse, which may suppress workforce or talent in creative industries due to a lack of socialization and networking [121]. Additionally, in resource-constrained settings, access to corresponding technologies, such as smart phones, the internet, and digital financial services, increases market access [33]. In Kenya, homegrown digital finance platforms, such as M-Pesa, promote inclusive digitization [16,122]. As new online innovations increase access to the internet, new and preexisting online users must be protected from potential online threats, such as cybercrimes, that may result in data and financial loss [123]. The effectiveness of firms' in managing innovative platforms and complementarities are fundamental to building partnerships and better serving low-income markets. Transformative finance partnerships must be created by capitalizing on the complementary strengths of Fintech companies and traditional financial institutions [124]. In financial markets, land ownership is the collateral security that increases accessibility among vulnerable groups. It is therefore imperative that governments create land ownership programs that address the needs of vulnerable groups. Furthermore, in the majority of SSA countries, delayed conflict resolution has remained a key barrier to the stabilization of financial markets' [125,126]. Thus, the success of post-pandemic transformation depends on the interplay of various AI-related, internet-related, digital, financial, socio-economic, and political transformations. It is interesting to note that policy innovations in the three case countries were cross-sectoral responses addressing issues related to finance and the economy, labor, social protection, stimulus packages, and violence against women. In the transformative plan, the management of AI, internet, digital, financial, socio-economic, and political innovation, is the function of the fourth pillar. Pillar 4 in Fig. 9 is known as *transformative innovation administration.*

Fifth, some observed barriers to post-pandemic transformations are region specific, and they therefore merit a regional transformative response. A regional organ can coordinate green finance and sustainable energy markets. This study proposes the creation of a regional organ, AEU Company that manages green finance activities, such as raising money through the sale of bonds and shares at an ASE. For example, the renewable energy program in South Africa raised ZAR 150 billion in domestic investment [91]. At the local level, AEU activities can be aligned with digitization and financial and literacy platforms strengthening pillar functionality. This alignment can assist in the management of complex energy transitions. Green growth is promoted through interventions, such as green finance for digitization; the creation of special funds; digital finance platforms; innovative finance programs; and results-based finance. For local, national, and regional actors seeking to increase green finance in SSA, the AEU offers unlimited opportunities. Pillar 5 in Fig. 9 of the transformative plan is known as *transformative AEU*.

Sixth, post-pandemic transformation tends to be successful when the structure of the electrification system that promotes universal access to electrification is multidimensional meaning that it is adequate, available, reliable, affordable, legal, convenient, healthy, safe,

and efficient [14]. That structure is also compatible with green technologies and services. However, evidence generated from multidimensionality studies suggests that desirability or ownership of technologies, appliances, and services does not necessarily translate to usefulness or applicability [14,15]. Although successful technology adoption is shaped by global, regional, national, and sub-national efficiency standards [14], context- and location-specific green technologies and services better serve local needs in underserved or peripheral regions. This includes customization of technologies and services to address context-specific challenges. For example, while energy practices, such as electricity tariffs in Egypt (see Table 1) reduced vulnerability in the built environment, including homes and business premises, other fragile and vulnerable identities are mobile and homeless (see Table 2). Electricity tariffs were unable to reduce fragility and vulnerability among people living in mobile homes or for those who are homeless. Nonetheless, some policy innovations promoted the installation of photovoltaic and net metering innovations, which had emerged as profitable at the peak of the pandemic and are mostly suited for installation in the built environment [127]. Other innovative technologies, such as the high-speed internet connected in the city of Mannheim, Germany, were instrumental in the tracking of COVID-19 figures among underserved internet users, such as visually impaired citizens in peripheral areas. Moreover, some locally produced, energy-efficient cooking technologies, such as the Lambamoto, or "Wonderbag,"[7] which can function without an electricity connection, are suitable for adoption in resource-constrained settings and can be paired with other modern cooking technologies [15,128]. In addition, multipurpose, energy-efficient appliances at the local level can address the needs of multiple vulnerable identities, such as food preparation, health access, communication, business enterprise, education, training, or capacity building [15]. Other innovative technologies for the management of global supply disruptions include last-mile delivery techniques, such as COVID-19 vaccine administration and related cold-storage infrastructures. For example, the Pfizer vaccine must be stored at a temperature of minus 70 $^{\circ}C$, which is colder than the typical winter in Antarctica. Meanwhile, the Moderna vaccine requires freezing at minus 20 $^{\circ}C$. Additionally, new industrial technologies are hydrogen based and require carbon capture and usage of storage facilities in resource-constrained settings. Multiple-criteria decision-making represents one of the methodologies for hydrogen site selection. Further exploration and development of location-specific methodologies should be pursued to address specific needs [129]. For example, multiple green-oriented construction practices demand energy-efficient materials, such as polyurethane [130]. In addition, technological exaptation can reduce vulnerability during crisis events. For example, the drugs Remdesivir and Tocilizumab were adopted in environmentally threatening contexts [131]. The function of the sixth pillar is the promotion and management of complex energy transitions and bottom-up innovation. It facilitates the demand and accessibility of user-friendly technologies for local actors' [6,16]. The pillar is known as *green transformative technologies specific to the location and context,* or Pillar 6 in Fig. 9.

Seventh, there is no development case without a business case. Specifically, the suitable business case is justifiable at the strategic level based on options, benefits, commercial costs and benefits, potential risks, and time lags in benefits delivery [132]. For the transformative business case under development, computations for transformational system gains or losses can inform green development decision-making. Business case is complementary to the Industry 4.0 value proposition with effective participation as the determinant driver and capability [87,133]. For example, EU partnership and actorness are considered the stabilizer of Egypt's energy policy [134]. EU partnership and actorness are also evident in Egypt's stimulus package (see Fig. 5) while South Africa is capitalizing on global partnerships for green finance (see Fig. 7), and Nigeria is dependent on national resources. Beyond financing economic recovery through government resources, global partnerships, and EU actorness, another driver of the post-pandemic transformation is efficient appropriation of investments. For example, sustainable energy projects that maximize the hydroelectrical power potential in SSA also reduce fossil fuel dependency [62]. The development of sizable hydro-based irrigation schemes improves the production potential in resource-constrained settings. In Zimbabwe, the highest and largest inland water body, which has a height of 89.2 m and a storage capacity of 1.8 billion m^3, was constructed for irrigation and hydro power generation [135,136]. For viability, hydro-based irrigation schemes can be connected to GVCs, such as those proposed in Egypt's stimulus packages for employment creation, strengthened food systems, and the promotion of healthy populations [137,138]. In resource-constrained settings, hydro-based irrigation schemes and GVCs can be complemented by structural market infrastructures for value addition and agro-processing, as highlighted by policy rationales for regional trade under the AfCFTA (see Fig. 8). Hydro-based development projects should mitigate the negative social impacts associated with dam construction, such as those associated with human drowning and crocodile attacks [136]. The function of the pillar is trade promotion for local economic development. It is known as *the transformative business cases or the value proposition* pillar in the transformative plan, or Pillar 7 in Fig. 9.

Eighth, even in developed countries, social variability in the implementation of Industry 4.0 is reported as complicating transformative integration [139]. Complementary alternatives to mainstream development approaches that are socially inclusive and shape technologies, require specific integration techniques. For instance, collective efforts are reported as complementary alternatives that were more instrumental in mitigating the effects of lockdown or isolation at local levels during the pandemic. Social norms such as *Ubuntu,* which translates to "I am because we are" [140], underscore the value of collective action in redressing energy injustices and promoting energy transitions. Ubuntu also encourages consensus building for the common good, another attribute of social equity. Moreover, the interrelatedness of Ubuntu over time is instrumental to intergenerational connections [141]. For example, people are wary of innovations that harm the environment, especially if they consider their environment an asset to be bequeathed to future generations. In general, most community approaches are complementary to resilience building that protects from shocks or crises [54]. Additionally, the role of grassroots women's groups can be articulated and mainstreamed in sustainable development. Popular developmental women's groups include the Stree Mukti Sangharsh in India, the Women's Coalition in South Africa, the Women's

[7] The Wonderbag, or Lambamoto, is a local South African innovation that was designed in Durban, South Africa in 2008 and is socio-culturally acceptable [128].

movements in Nigeria, Action for Development in Uganda, and Danish women's movements. As membership can include both sexes, men can participate in equity issues of interest to them. Such participation promotes gender equity and social inclusiveness in local energy transformation. Social norms that are adaptable in innovative contemporary technological designs and options have societal and ethical dimensions and implications. Leach et al. recommends that post-pandemic transformations must revitalize neighborhood networks, religious groups, and women's networks [6]. Through the deployment of green technologies, innovative local businesses and sectors, such as local fashion design, can be transformed into modern GVCs [44,142] with national, regional, and global impact. The pillar promotes cohesiveness in local energy transformation, enriches transformative learning or unlearning, and encourages adoption of cultural theories and frameworks that are integrative and assist with the interpretation of complex energy transitions [36, 143,144]. The pillar is known as *transformative alternatives to mainstream perspectives*, or Pillar 8 in Fig. 9.

Ninth, the responsible research and innovation paradigm calls for integrated and comprehensive understanding [145]. Locally driven gender-equitable, structurally equitable, and green-transformative pathways inform local processes and localized post-pandemic energy transformations. The responsible research and innovation paradigm promotes local economic development and reengagement in global supply chains (see the Introduction and Table 1 for disruptions in energy practices and Fig. 8 for policy rationales for green transformational success). The paradigm stimulates local ownership of economic development and energy projects. For example, some local initiatives, such as CP, promote social inclusivity and encourage the identification of local needs and the inclusion of academia and industry stakeholders in problem-solving [49,146]. Despite CP's instrumental role in community development through improved local ownership and management of energy systems [49], energy frameworks in the three case countries do not have a CP component. Meanwhile, in Belgium, successful cooperatives that specialize in electricity retailing such as Eco Power and BeauVent were established in 1991 and 2000, respectively. Eco Power has 22 full-time workers, 47,419 members, and EUR 48,328,750 total cooperative capital. BeauVent has 537 full-time workers, 2,391 members and EUR 4,781,500 total cooperative capital [147]. Such local economic activity can prevent transportation challenges such as congestion, associated with commuting to distant economic zones. During COVID-19, telework increased opportunities for flexible work arrangements because most workers participated remotely. Although the services sector was more successful as a result of digitization opportunities, the raw materials sector, where vulnerable groups participate at the lower end of the value chain, require capacity building in green skills and jobs. Responsible research and innovation are focused on the coexistence and augmentation of new and preexisting jobs threatened by digitization at the local level. In South Africa, the REIPPPP oversees all programs under development. One coal-fired power plant about 1,500 MW under construction is for ensuring job security during transition [148]. Job security is to be managed during transition because coal is the abundant resource in SSA. In China, renewable energy technologies are manufactured in coal power plants. The function of the pillar is local capacity development of the local energy system. In the post-pandemic transformation plan, it enriches the post-structuralist approach with local science and evidence for policy. It is known as the *transformative localization and reengagement in global supply chains pillar*, or Pillar 9 in Fig. 9.

Tenth, in the case of economies emerging from a crisis, achieving success in innovative governance for systemic transformative energy policy can be complex as the pivotal transformative drivers are both interdisciplinary, and multidimensional. It involves systemic learning and management of transformative pathways. Governments must efficiently manage transformed practices, beliefs, values, and assumptions to address the diverse needs of fragile and vulnerable groups. Innovative governance for transformative energy policy can assist policy innovators to address systemic failures. Then transformative deliberation consists of transformative processes, and continuous learning, and unlearning [62]. When there is technological and market uncertainty, lower commitment levels are required for reversible governance modes [149]. In addition, complementary alliances may take various forms, such as technology-driven, business-led, state-supported, and citizen-led transformations or alliances centered around sustainability, political decisions, and movements challenging established interests, deeply rooted in fossil fuel capitalism [6]. COVID-19 exposed vulnerabilities in the energy system, such as the dependence on for-profit energy systems for basic services while energy systems are controlled from outside the community and dependent on imported renewable energy technologies [55]. Since countries in SSA lack local industrialization capacity, local innovative governance for transformative energy policy can be strengthened through the adoption of internationally effective tools, committed development partners, financing organizations, and dedicated leadership [55]. However, the COVID-19 pandemic affected all aid partners equally, and development assistance to SSA at the time was not a priority. Transformative local financial management is a priority for all governments in SSA. Local financial management capacity can include executive orders such as debt forgiveness and income-based utility rates that prevent electricity shutoffs [53]. As discussed earlier, South-South trade that is currently low and green [17] can be transformed locally to focus on capital goods for industrialization [150]. Appropriate incentives for different segments of the renewable energy value chain can accelerate and benefit this transition [24]. Governments of LMICs can expand the green-transformative trade networks between the countries of the Global South.

Over time, post-pandemic revisions of policy innovations and concepts deployed across the renewable energy value chain need synchronization. Although most nations implemented strict lockdowns, policy innovations (see Fig. 4a) lacked a clean energy strategy [57,59]. For example, the just transition that is clearly articulated in the green stimulus packages of the case countries may be problematic from two perspectives: the lack of a clearly acceptable universal definition and the difficulty of implementing just transitions [54]. Kuzemko et al. offered three management solutions. The first solution is balancing the relationship between the global drop in oil prices and renewable energy. The second solution is an assessment of whether policy responses will have a short or long-term impact on energy behaviors. The third solution is a consideration of the differences between nation states and the willingness of oil-producing countries to pursue renewable energy pathways [56]. It is evident from the derived transformative pathways (see Fig. 4a, b, 4c, and 4d) that management capacities are high. Inevitably, new politics should accompany transformative governance for transformative energy policy. Transformation needs considerable vision and, over time, determination from political and social forces to overcome resistance from established ideas, interests, practices, organizational governance, and transition management

[151]. For example, COVID-19 demonstrated the complexity of global efforts to drive change at the local level. Nevertheless, numerous innovative approaches to foster a climate-friendly transition have emerged in various countries with the support and leadership of sub-national states [151]. For example, while Egypt, Nigeria, and South Africa have established comprehensive policies (see section 3.1), it is imperative to promote network governance within and across the African continent. An instructive lesson can be gleaned from the Dutch energy sector, highlighting the influence and dominance of industry and government elites [46]. Nations can maximize the value of mediation by political institutions, which promotes sustainable change and continuity, specifically interactions between governance and practice change within systems [152]. It is important to facilitate the participation of sub-national authorities in energy policy so that they become active rather than passive implementers and innovators of energy policy [51]. The government of governance "governmental governance" also affects the prevailing policy, regulatory, fiscal, and legal environments. For example, resource availability may not be the only precondition of economic viability because countries with moderate annual solar energy like Germany became leaders in photovoltaic solar energy systems following government interventions [52].

Globally, approximately 30 % of the stimulus packages will be allocated to environmental issues. Environmental inclusivity is therefore appropriate. Although Egypt's transformative pathways articulated the 41 environmentally friendly projects (see Section 4.3.1), environmental inclusivity can strengthen post-pandemic transformations. Environmental inclusivity refers to the construction of meaningful pluralistic structures and processes as a potential mechanism for the prioritization of environmental concerns and the anchoring of energy policy [153]. Elsewhere, fluid governance arrangements have been employed to exploit each actor's capacity to build trust at the foundation of co-produced models [48]. For example, while collaboration might aim to be inclusive of all interested actors, project designs that reflect community values, incorporate community control, and incentivize indigenous ownership are critical (see also Pillar 8 in Fig. 9). In India, regulatory and governance issues that have a bearing on the renewable energy sector have been considered key, such as technical and institutional capacity, planning and budgetary allocations, transparency and accountability, regulatory compliance, and social and environmental concerns [47]. In Brazil and Germany, decision-makers' problems and solutions in transboundary policy-making differ widely due to the manifestation of policy contexts and self-interests. In such a scenario, research suggests that rather than focusing on the fragmentation of stakeholder interests, the focus should be on boosting financial resources, technical expertise, and legislative capacity, which are the more powerful drivers of policy formulation, policy implementation, and the revision of policy gridlocks [154]. The tenth pillar's function is improved coordination and overall transition management. In the post-pandemic plan, the pillar is known as the *transformative new politics* pillar, or Pillar 10 in Fig. 9.

Finally, I categorized The Muza 10-PLP$_4$IG$_4$TEP (see Fig. 9) according to primary interlinkages to gender-equitable, structurally equitable, and green-transformative pathways. For example, the 10 pillars categorized in Fig. 10 support the notion that pillars 1 and 8 are primarily gender-equitable, that pillars 2, 3, 4, 7, and 10 are primarily structurally equitable, and pillars 5, 6, and 9 are primarily green-transformative. The need for more structurally transformative interventions supports the notion that COVID-19 exposed challenges that have always existed in the global system and that transformative interventions must promote transformative R&D to increase understanding on the nature of interventions that redress long-standing structural issues and histories of inequities [6,7] and firms' incapability [12]. However, the overarching transformative pathway come full circle following an established sequence: gender-equitable, structurally equitable, and green-transformative outcomes. The study further suggests that although the 58 policy innovations were inequitable, the transformative potential is strong and promising in terms of gender, structure, and sustainability. Hence the need for governments to implement transformative interventions to promote future resilience.

6. Conclusion

The development and sustenance of gender-equitable, structurally equitable, and green-transformative pathways is an evolving, complicated, and multifaceted agenda. It required that I move backwards and forwards throughout the research process. Braun and Clarke [88] suggest that though the six-steps of RTA are organized in a sequential order, the analysis is not a linear process of moving forward through the process. While RTA values the researcher's role in knowledge production, it has been criticised for allowing the researcher to bring their own assumptions about the nature of reality, what constitutes meaningful knowledge and knowledge production, what their data represent or give them access to Ref. [88]. RTA is about the researcher's reflexive and thoughtful engagement with their data and their analytic process, it is fully appreciated or even expected that no two researchers will intersect this tripartite of criteria in the same way [88]. I am curious to learn how other researchers will adopt and/or adapt the transformative approach adopted in this study. I leave it to the reader to determine if the approach is useful in helping them to reflect on their own research questions, themes, theoretical underpinnings, and policy learnings. While the post-pandemic policy framework provided scope for innovative governance for transformative energy policies, the inclusion of all important elements in only 10 pillars proves to be an impractical task. I am optimistic that the quality of related research publications will rise further, as teams of supportive practitioners, researchers, reviewers, and editors have interest in knowledge generation from a multidisciplinary approach. The concept of the paper has evolved over a decade of experiences from varied global and local events such as financial, pandemics, droughts, and conflicts. It was initially developed in 2010 as a follow-up to preliminary studies that mapped local vulnerabilities [138,155] and from which other related work was developed [137,156–159]. Since then, the paper has gone through many iterations and has benefited significantly from each. However, the emergence of COVID-19 transformed the paper.

The innovative theoretical framing was derived from three innovation concepts: reflexivity, transformative unlearning, and intelligent failure. Reflexivity was instrumental in the deliberation of COVID-19 practices and advanced transformation in unlearning beliefs, values, and assumptions of policy innovations for the identification of green technologies and green-transformative services. The study applied a coded policy narrative and transformative index-matching technique on 58 policy innovations implemented in SSA's three largest economies—Egypt, Nigeria, and South Africa—during COVID-19. The study found transformative pathways to be

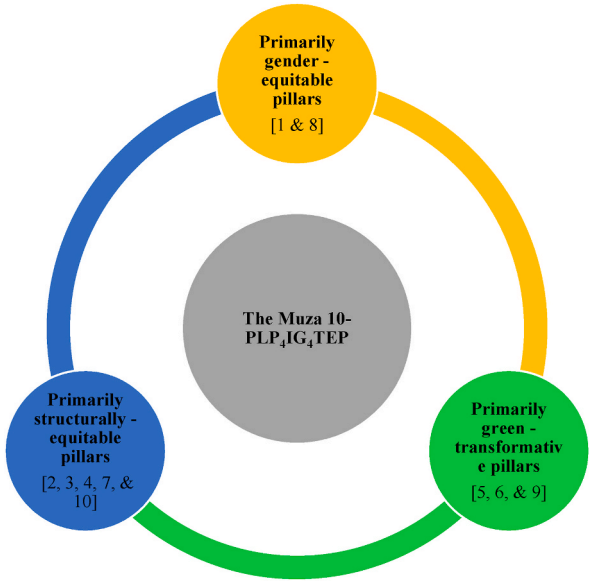


Fig. 10. The Muza 10-PLP_4IG_4TEP according to primary contribution to three pathways.

gendered, structural, and green-transformative. The main study implication was that intelligent failure promotes systemic learning for innovation governance for transformative energy policy. However, for innovative governance of transformative energy policy, green transformative success is dependent on the form and function of the post-pandemic plan.

The first pillar involves *gendered and transformative perspectives that align locally, regionally, nationally, continentally, and globally* (Pillar 1 in Fig. 9) for monitoring structural equities (or inequities) across and within scales. The second pillar is *the transformative tipping point vs. turning point* (Pillar 2 in Fig. 9) maintaining the desired change and continuity; *a transformative socio-ecological justice framing at the local level* (Pillar 3 in Fig. 9) reducing fragilities and vulnerabilities. The fourth pillar is *transformative innovation administration* (Pillar 4 in Fig. 9) promoting rigor in the implementation of COVID-19 mechanisms. The fifth pillar is *transformative AEU* (Pillar 5 in Fig. 9) raising green finance for inclusive digitization. The sixth pillar is *transformative green technologies for place and context specificity* (Pillar 6 in Fig. 9) for useful and valuable technologies. The seventh pillar is *transformative business cases and value proposition* (Pillar 7 in Fig. 9) ensuring firm or institutional capabilities. The eighth pillar is *transformative alternatives to mainstream development perspectives* (Pillar 8 in Fig. 9) socializing the energy system inclusive of local practices, norms, and technologies. The ninth pillar is *transformative localization of the energy industry* (Pillar 9 in Fig. 9) stimulating local industries. The tenth pillar is *transformative new politics* (Pillar 10 in Fig. 9). Innovative governance is governance of the future or transformative governance of the future energy system that creates and sustains pathways: gender-equitable (pillars 1 and 8), structurally equitable (pillars 2, 3, 4, 7, and 10), and green-transformative (pillars 5, 6, and 9).

7. Limitations and future work

Although this study demonstrated post-pandemic transformative capacity, it was guided by two assumptions. First, policy innovations can be transformed and second, all actors are interested in post-pandemic transformations, and complementary institutions are supportive. Reflexivity approaches may suffer from researcher and contextual biases. Thematic analyses may neglect critical policy innovations if a related theme is excluded. Consultation of scientific and non-scientific sources, integration of different theoretical techniques, and analysis of a large number of policy innovations and stimulus packages broadened the scope of systemic learnings. However, the causalities of or associations between these themes were not explored. Follow-up work should focus on quantitative assessments to determine the nature of relationships between the transformative variables for all countries in SSA. This study focused on countries in SSA and investigated the green pathways of the region's three largest economies, areas that are not particularly low-carbon in terms of green growth development. Their green pathways may not apply to other developing economies that are not dependent on oil. Future research could focus on applying this policy to other developing economies. In addition, future studies could compare the energy pathways of the three largest economies in SSA with those of other large economies in Asia, Europe, and Americas, to increase the transformative knowledge base. This study used COVID-19 responses, which continue to shift as the pandemic progresses. At the time of writing, short-term and stimulus responses to COVID-19 were ongoing. Further studies could investigate the structural equities of new policy innovations. Although experimentation techniques provide room for policy failure, learning, and repetition, the realization of meaningful results for replication requires considerable time. For example, over a decade of experimentation with RCT designs and the household as a decision-making unit "black box" has been required for my forthcoming work on multidimensional and transformative renewable, climate, agricultural, education, health, digitization, and gender policies.

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Ethics statement

The study followed the ethics requirements at the University of Rwanda. Data was collected from secondary sources and the detailed data and policy toolkit are available as a separate publication.

Data availability statement

Data used for the research is available as a separate publication. See the additional information section.

CRediT authorship contribution statement

Olivia Muza: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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