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Towards more sustainable and inclusive development corridors in Africa

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Abstract

Development corridors are linear programmes of infrastructure and agriculture aiming to facilitate rapid socio-economic development. In Africa, they are a major development activity, with 88 underway or planned corridors. Drawing from extensive literature and insights

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gleaned from a 4-year research programme, this review scrutinizes the impacts of development corridors on people, wildlife and ecosystems in Kenya and Tanzania, proposing solutions to achieve better outcomes. The overarching goal was to discern the principle challenges emerging from the practical execution of the prevailing corridor model. The holistic approach taken, assessing the development corridors paradigm through an integrated ecological, social, and economic lens, provides novel insights that have not been possible using more traditional – siloed – research approaches. Eight key challenge areas are identified: impact assessments processes; coherence across international, national and local planning; governance; inclusivity; equality; impacts on biodiversity and ecosystem services; incorporation of future climate risks; and integrated water resource management. Poorly planned and implemented corridors detrimentally impact livelihoods and ecosystems. They lack a sustainable development vision, detailed social, environmental or climate risk assessments, and develop incrementally in policy and corporate spaces. There is also often a disconnect between investors and recipient governments, with some investors funding what governments request without applying internationally-recognised safeguards, and governments lacking capacity and resources to enforce regulations. We make recommendations for addressing these challenge areas. These aim to enhance impact assessment efficacy; integrate local perspectives into effective and inclusive corridor planning; overcome siloed project development and implementation; anticipate future development projections; and prioritise landscape preservation for enhanced ecosystem services and climate resilience.

1. Introduction

1.1. What are Development Corridors?

Development corridors are large, linear, and often transnational geographical areas targeted for investment [1–6]. Conceptually, corridors evolve over time from transport corridors (the

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simplest manifestation) through to programmes aiming to achieve multiple social and economic objectives [7]. They frequently involve clustering of investments, logistics, and market integration and are formed with links to different national spatial development initiatives [8–10]. Development corridors are a global phenomenon spread in all continents across the globe [6]. A notable example of scaling development corridors to the global scale is the Belt and Road Initiative (BRI). Launched in 2013 and led by the Chinese Government, this initiative has connectivity of infrastructure as one of its five priority areas [11], and comprises six main economic corridors; China-Mongolia-Russia Economic Corridor, New Eurasian Land Bridge, China-Central Asia-West Asia Economic Corridor, China-Indochina Peninsula Economic Corridor, China-Pakistan Economic Corridor, Bangladesh-China-India-Myanmar Economic Corridor [12]. The BRI encompasses nearly 70 countries and international organisations, one third of global trade and GDP and impacts 60 per cent of the world's population [13,14]. However, as with other corridor initiatives, concerns about the BRI adequately addressing social and environmental impacts have been raised [15].

Practically, corridors are implemented in a series of phases with variable duration, involving diverse actors depending on the context (Fig 1). In principle, these phases provide opportunities for corridor impacts to be assessed (adapted from [6,7].

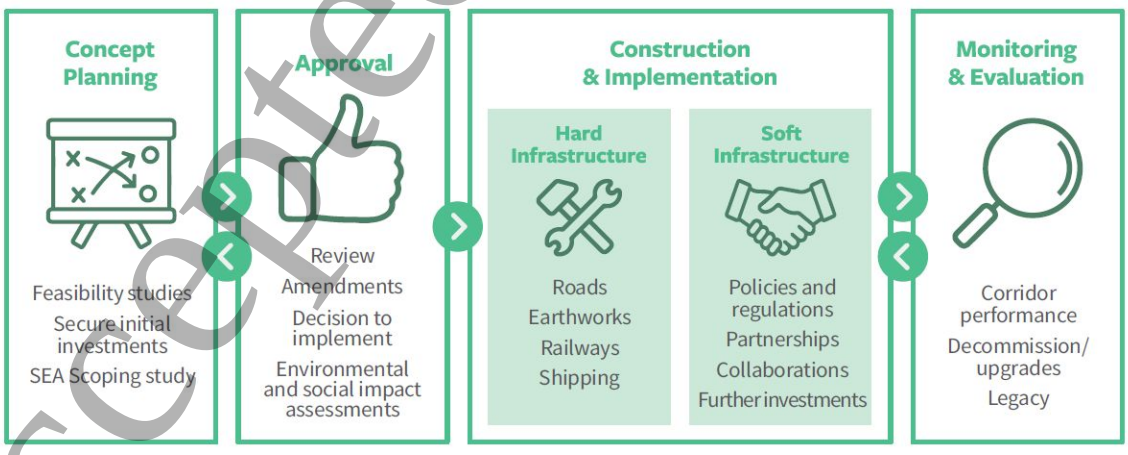

Fig 1. Phases of development corridors *[adapted from Juffe-Bignoli et al. 2021]*

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Several positive societal outcomes are envisaged through development corridors [16]. However, limited evidence exists regarding the efficacy of development corridors in enhancing the lives of people in developing nations, especially those already in poverty or marginalised from mainstream development. There is some evidence that large-scale transport infrastructures associated with corridor development amplify preexisting social and economic disparities [17–19], while causing considerable ecological damage [20–24]. Moreover, part of the failure of development corridors to fully realise their potential could stem from compartmentalised, siloed strategies or limited scopes of defining objectives and gauging measures of success [1,8,25,26].

Acknowledging the significance of these investments for national development and their capacity to deliver both favourable and adverse impacts, the United Nations adopted a key resolution on sustainable and resilient infrastructure at the 5th United Nations Environment Assembly in March 2022 (Box 1), now in the process of implementation.

Box 1: United Nations Environment Assembly resolution 5/9 on sustainable and resilient infrastructure adopted on 2 March 2022

This resolution [27] encourages Member States and other stakeholders to undertake key actions, with the most relevant for development corridors summarised below:

Consider integrating and implementing the 10 “International Good Practice Principles for Sustainable Infrastructure” [28] into national policies;

Implement existing tools, such as guidelines and best practices, including those developed under or endorsed by multilateral environmental agreements;

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Cooperate internationally to strengthen frameworks, including for financing, for sustainable and inclusive infrastructure that maintains and enhances ecological connectivity, avoids further fragmentation, and minimizes other potential impacts on ecosystems and livelihoods;

Conduct strategic and environmental impact assessments so that environmental considerations are integrated into decision-making at appropriate levels;

Promote investment in natural infrastructure and nature-based solutions for delivering essential services and improving ecosystem services, creating employment and accelerating the achievement of the Sustainable Development Goals;

Promote investment in infrastructure that is environmentally, socially and economically sustainable, climate resilient, resource efficient, that prevents ecosystem fragmentation and contributes to sustainable production and consumption patterns;

Provide opportunities for the engagement of relevant stakeholders, including local communities, vulnerable people and indigenous peoples, in all stages of the process to identify, design, build and maintain infrastructure.

1.2. Development Corridors in Africa

African nations propose to implement at least 88 major development corridors over the coming decades [2,24]. These corridors typically aim to stimulate economic activity, involving the construction of various types of linear infrastructure projects, intertwined with agriculture and natural resource extraction [3,6,24,29]. The main transport investments for African development corridors are roads (34.8%), ports (20.7%), railways (17.9%) and airports (7.6%). Additionally, corridor investments commonly entail the development of resort towns, electricity transmission lines, dry ports, industrial parks, and water pipelines. These undertakings represent significant investment, ranging from USD 547 to 659 billion [2]. Exacerbated by protracted, long-term investment horizons and contractual repayment

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agreements, these projects have the potential to lock in development trajectories of African countries for decades, constraining the capacity of these countries to adapt to evolving circumstances.

Here, in a unique interdisciplinary study, four years of field-study and policy-synthesis undertaken through the Development Corridors Partnership (DCP) work in Africa (Box 2) are reviewed and synthesised into eight challenge areas concerning the implementation of corridors. This includes original works published by DCP, but also additional relevant literature not produced by the partnership. Available solutions to overcome these challenges are also explored, as well as final recommendations for more sustainable development corridors in Africa.

Box 2. The Development Corridors Partnership project

The Development Corridors Partnership (DCP) project ran for four years from 2018 to early 2022 [30], aiming to enhance the understanding of development corridors and their contribution to delivering the Sustainable Development Goals (SDGs). This interdisciplinary project involved anthropologists, social scientists, ecologists, biologists, hydrologists, climatologists, and those with development expertise. The research scope was to study selected corridors in Kenya and Tanzania, map development corridors across Africa, and learn from similar interventions in China. The aim of the project was to develop an understanding of development corridor practice within these geographies and learn lessons that are applicable globally. Almost 150 outputs were produced by DCP, using insights gathered from thousands of people in Kenya and Tanzania – and technical experts from Europe and China - who are either benefiting or being affected by development corridors, have invested in them, are involved with planning, or are implementing them on the ground. All DCP resources are openly accessible online (Supplementary Data) [31].

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2. Methods

2.1. Overall approach

DCP's research methodology primarily employed an inductive approach, amalgamating qualitative and quantitative data collection techniques. This included extensive field work led by DCP, literature reviews, expert consultations, and national workshops. In total, excluding workshops, 149 publicly available outputs were produced, including 54 peer reviewed journal papers, 24 book chapters [7], 11 policy briefs, 11 webinars, 10 reports, training materials, an e-learning course, and a series of workshops in China (n=2), Tanzania (n=13), Kenya (n=13) and the UK (n=3). These outputs are summarised in Supplementary Data.

Building from the results of the DCP project, the overarching goal of this paper is to summarise the main challenges emerging from the practical execution of the prevailing corridor model, and explore potential remedies for those challenges. Such holistic approach assessing the development corridors paradigm through an integrated ecological, social, and economic lens has not been done before. Here, DCP researchers delineate eight challenge areas, for which solutions to identified issues are scrutinized, culminating in final conclusions and recommendations. Where relevant, knowledge, resources and research not led by DCP are also included. Although the Development Corridors Partnership concentrated its efforts in Kenya and Tanzania, it brought in insights from China and strived to extrapolate its findings to draw conclusions and solutions applicable to a global context.

2.2. Study sites

In Kenya, the research focused on the Standard Gauge Railway (SGR) and associated road and infrastructure developments including the Lamu Port, South Sudan, and Ethiopia Transport corridor (LAPSSET) [32] (Fig. 2). The SGR stretches from Mombasa to Nairobi and is planned to extend to Uganda and further west. The aim is to increase the ease of

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travel between large cities, facilitate freight transport and establish local development hubs along its route. The SGR[33] has reduced travel time between Mombasa and Nairobi from over ten hours to four. Between 2018 and 2020, annual passenger numbers surged from 1.6 to 4.7 million, while freight volumes increased from 258,000-1.1 million TEUs (Twenty-foot container Equivalent Units) [34]. However, the SGR traverses two National Parks, bisects wildlife migratory corridors [35] , which spurred local opposition and resulted in several litigations over the years [19,33], and has affected the region's hydrology and access to water for both people and wildlife [3]. China has invested in the Standard Gauge Railway, providing bilateral financial loans from the Exim Bank of China [33] for infrastructure projects and construction and operation services [36–38]. Although, the SGR funding from China was discontinued without finalising the initially planned trajectory reaching Uganda ([33,34], new efforts to moblise funds to finalise the project are underway [39,40] .

In Tanzania, the focal corridor of research was the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). This agricultural development corridor runs from Dar es Salaam across a large swathe of central Tanzania [41] (Fig 2). Development efforts have concentrated on establishing agricultural clusters and improving infrastructure to facilitate the transportation of crops such as tomato, soybean, dairy, and potato, tea to market. By 2019, over 100,000 smallholder farmers had partnered with SAGCOT Centre-associated private companies, with 41,000 smallholders adopting improved technologies and investing over USD450 million in new businesses [42]. Since its inception in 2013, the corridor has established structures to promote active engagement from government, NGO and private sector partners. A multi-stakeholder "Green Reference Group" [43] and corresponding environmental and social "feeder groups" have been established to provide guidance on issues related to inclusive green growth[44].

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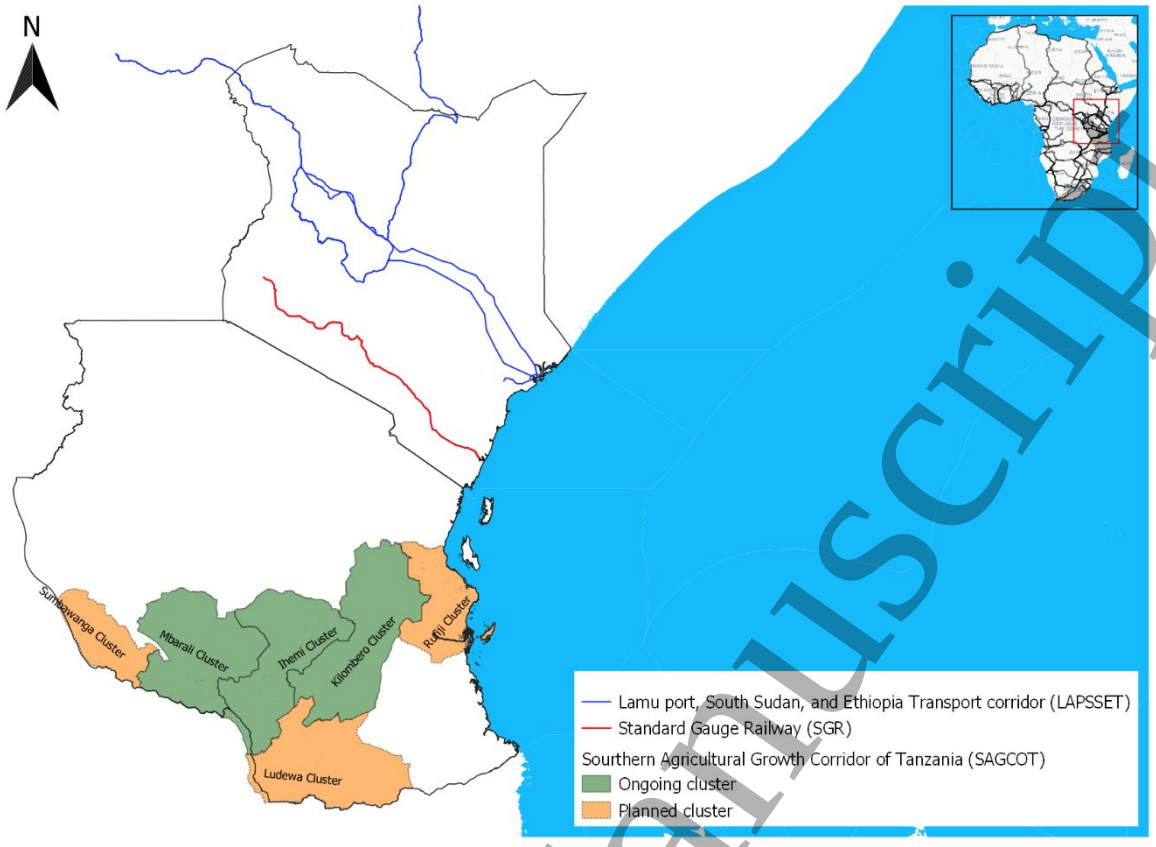

Fig 2. Location of development corridors in Kenya and Tanzania that formed the focus of this synthesis. SGR: Standard Gauge Railway. LAPSSET: Lamu port, South Sudan, and Ethiopia Transport corridors. SAGCOT: Southern Agricultural Growth Corridor of Tanzania).

2.3. Data collection

Primary data were collected, combining quantitative and qualitative methods, through numerous field work programmes between 2018 and 2021 in Kenya and Tanzania. Qualitative data collection included semi-structured and structured interviews (e.g. [33]), participatory scenario workshops (e.g. [45]), household surveys (e.g. [35]), reviews (e.g. [6]), Q-methodology (e.g. [8]), climate vulnerability assessments (e.g. [46]) and ethnographic fieldwork (e.g. [17]). Quantitative data collection included land cover change analyses (e.g. [3]), spatial analysis of wildlife corridors (e.g. [47]), digitising implementing, ongoing and planned development corridors (e.g. [2]), and hydrological modelling (e.g. [46]). This research was supported by secondary data retrieved from existing literature on the topic as

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well as from publicly available spatial databases on infrastructure projects, protected areas, land cover, biodiversity, and hydrology. A notable example of spatial analysis was gathering information on ongoing and planned corridors across Africa to create a spatial temporal database of development corridors in Africa. This consisted compiling road data from public websites and impact assessment reports and use these to, supported by satellite imagery, delineate, and validate 88 corridors projects in Africa [2].

Complementary insights were obtained through several training courses, collaborative workshops, and extensive stakeholder consultations, as well as desk studies (see Box 2). The study topics ranged from social anthropology [5,17], biodiversity impacts [4,6], land use change analysis and scenario building [3], hydrological modelling [48,49], impact assessment [2,7], policy [8,50], critical geography [17–19], among others.

3. Eight challenges in the current development corridors model

The research findings of DCP are summarised below into eight key challenges development corridors currently face. Each issue includes a heading, the issue summarised in one sentence, and a brief narrative with supporting evidence.

3.1. Impact assessment processes: Poor application of existing best practice guidance in development corridors results in adverse outcomes for people and nature

Existing best-practices for designing, implementing, and monitoring the progress of large-scale development projects are not adequately applied by Eastern African and Chinese corridor development partners ([6,7,15]). Strategic Environmental Assessments (SEAs) and Environmental and Social Impact Assessments (ESIAs) are mandated by law in Kenya and

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Tanzania, but many do not follow international best practice [7,44,51]. In Tanzania, despite a strong legal framework for Environmental Impact Assessments (EIAs), and the presence of relevant expertise and quality assurance mechanisms, weak coordination, and limited political will to implement best practice hinders EIAs from realising their full potential [51]. Furthermore, safeguards commonly applied to grants and loans for large-scale schemes have not always been utilised in both Kenya and Tanzania [11,15]. This has resulted in avoidable environmental damage that could have been avoided and impacts on local communities resulting in conflicts over land allocation [52]. Finally, not all large-scale developments have monitoring and evaluation systems in place to ensure current and future adverse outcomes are understood, measured, and addressed [53].

3.2. Planning coherence: Poor integration across sectors and scales generates unintended cumulative impacts

Nationally, there is often inconsistency between corridor development and other government plans [2,45]. Overlapping and often conflicting land use planning and ownership result in multiple claims being made to the same areas of land for different uses. For example, corridor plans intersect across Kenyan and Tanzanian national land use and development plans, often affecting implementation. In addition, governments have committed to various Multilateral Environmental Agreements (MEAs) to develop plans to conserve habitats, species, reduce carbon emissions, protect areas of high carbon sequestration potential and safeguard water resources. These MEAs include the UN Framework Convention on Climate Change (UNFCCC), the UN Convention to Combat Desertification (UNCCD), the Convention on Biological Diversity (CBD), the Convention on Migratory Species (CMS), the Ramsar convention on wetlands, the UNESCO World Heritage Convention, or the Sustainable Development Goals (SDGs). However, corridor planners often lack the capacity to fully consider these commitments and/or are unaware of them or their responsibilities towards

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them. Moreover, corridor planning requires greater alignment with local government and village land use planning processes, yet this coordinated and integration with corridor design and implementation is often lacking [45].

3.3. Effective governance: Fragmented and non-inclusive governance hinders effective implementation

In the public sphere, corridors intersect with the institutional mandates of government departments seeking diverse public benefits. However, these are not always mutually reinforcing. Thus trade-offs between public and private benefits that develop incrementally can arise within a landscape [8,25]. To enhance governance and coordination, governments sometimes establish a single national focal point (e.g., LAPSSET Corridor Development Authority, SAGCOT Centre). However, their capacity to evaluate the delivery of development goals within their mandates remains limited, often due to the absence of policies that consider development trade-offs and impacts [8,25]. Governance systems for corridors need to involve policy makers, land officers, extension staff, protected area managers, and civil society working with communities at the village, local and national levels [53]. Despite their power in the development discourse, corridors often remain rather nebulous and fragmented, lacking a coherent development plan or overarching oversight to manage development trade-offs and synergies. Better strategic governance to ensure oversight, planning, and coordination would enhance impact and catalyse sustainable development.

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3.4. Consideration of inclusivity: Historically marginalised communities are not meaningfully consulted about corridor development planning, implementation, and functioning

Even when national legal regulations on community inclusion exist, they are often not effectively implemented, and most consultations remain informative processes rather than meaningfully seeking community consent [2,18,19,33]. This undermines development initiatives, results in inequities in the distribution of benefits during construction and operation, and creates significant investment risks [54].

In Kenya, historically marginalised communities were not meaningfully consulted about corridor development. Even though national legal regulations on community engagement exist, in the best-case scenario communities are simply informed about the arrival of development initiatives, as shown by both the SGR and LAPSSET [17–19]. This weakens long-term social inclusion at all stages of corridor implementation. For instance, in the Lamu Port in LAPSSET, there are impacts on local fishers, designated beach management units and rural communities through port development, loss of fishing rights [17] and reduced access to sacred forests [45].

Small- and medium-entrepreneurs feel differential impacts. While new railways and roads between cities can lead to more employment (e.g., contractors, tourism businesses and food vendors around construction sites), such infrastructure can lead to job losses for truck drivers, taxi drivers, container freight warehousing businesses, loaders, mechanics, and roadside businesses like restaurants and hotels [18,45]. Newly constructed infrastructure often by-passes rural areas, and poor rural communities face reduced transport options (e.g., Emali, Athi River in Kenya) [45]. Indigenous and pastoralist communities with no land

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titles lose access to, or are relocated from, lands used for agriculture without consideration of indigenous cultural identity and social ties [19,45,53,54].

3.5. Consideration of equality: development corridors tend to benefit already privileged socio-economic groups rather than helping improve the lives of more vulnerable groups

The modern development agenda and success indicators often overlook traditional livelihoods. For example, Lamu Port development has displaced over 4,700 artisanal fishers in Lamu county. Although the port construction began in 2012 and the High Court ruled that displaced fishers are entitled to financial compensation, these fishers have not yet been compensated [17]. Due to the Lamu Port development, the population of Lamu is expected to increase from 22,336 (2009) to slightly over 400,000 in 2030 [55]. Factors like religion, migration, poverty and water scarcity are likely to exacerbate conflict [56]. The SGR has resulted in the physical division of villages, loss of land and non-financial assets, and increasing social conflict [18,19]. For instance, land compensation for the land acquired for the SGR primarily benefited landholders with secure land titles, while individuals with insecure (often communal) land titles lost access to the land they had cultivated [19]. Inequalities arise concerning large-scale land acquisitions, which alter the distribution of resources and often detrimentally impact intercultural interactions. This is particularly evident when community groups that rely solely on one season of crops or one herd have limited options to diversify their livelihoods. Growing inequalities undermine subsistence self-sufficiency, changes family structures, alters traditional labour roles, and can lead to outmigration [57].

Moreover, the development corridors narrative of “opening up” access to underdeveloped regions and decentralising development, does not seem to have materialised in the case of the SGR [1]. Governments often make commitments to deliver broader interventions to

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structure enabling business environments that support entrepreneurship within corridors. Yet because governance of development corridors is often weak and fragmented such interventions have been slow to materialise. As corridors have often been manifesting merely as 'transport corridors', with uneven development gains, local communities are also finding themselves on the frontline of trade-offs and impacts that come with corridor development [1]. Development corridors therefore often appear largely premised on a linear model of development, which assumes infrastructure universally brings development, creates jobs and supports entrepreneurship in areas such as agricultural value chains. In practice, inclusive development, the type of which national governments have committed to deliver through the Sustainable Development Goals (SDGs), does not materialise from infrastructure development alone [1].

3.6. Impacts on biodiversity and ecosystem services: development corridor planning does not follow best practice to identify ecological or ecosystem service impacts or implement appropriate avoidance and mitigation measures

Poorly planned development corridors create problems when conservation areas are bisected by railways and roads. Upgraded (and faster) roads and railways in Kenya have led to an increase of road kills of wild and domestic animals [4,35]. The behaviour of animals in Nairobi National Park changed after the construction of the railway, with more species being found in the southern end of the park, avoiding areas of higher noise pollution and dust [45]. In Tanzania, local leaders observed that some animals (e.g., elephants), became more

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aggressive in the presence of traffic noise in SAGCOT [58] and richness, diversity and abundance of insect pollinators are affected by habitat modifications [43]. Moreover, land conversion impacts other ecosystem services; for example, converting cropland results in loss of carbon, pollution, increased sediment loads and alternations in annual/seasonal water yields [3,48].

3.7. Incorporation of future climate risks: development corridors do not integrate climate or land use change risks and projections in their planning and implementation

Models of climate change in East Africa indicate that temperatures have increased and will continue to rise, while rainfall will become more variable [59,60], with higher frequency and intensity of extreme climatic events. Water-related risks, drought, heatwaves, extended dry seasons, flood risks are all expected to increase [61]. This will lead to societal damages, significant financial burdens, and other negative impacts such as crop pest outbreaks, changes in species distribution [60].

Despite the known climate challenges, there is low integration of climate risk into infrastructure planning in Kenya and Tanzania [49,62,63]. This is complex because different climate models project different patterns of rainfall, even for the same location. Hence, those planning development corridors need to account for a wide range of possible rainfall futures [53,64].

There remains a lack of understanding and practical examples on how to set climate change adaptation targets (e.g., nature-based solutions, climate smart agriculture) to address climate risks in different contexts [65,66], how to implement climate change adaptation actions in development corridors [65,67], and how to promote desirable futures [53].

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3.8. Integrated water resource management: Development corridors fail to fully consider adverse impacts on water quality, quantity, supply and demand

Development corridors frequently traverse water catchment areas, wetlands and water bodies – causing erosion and oil spills. The redirection of water into culverts often leads to gulley erosion, flash floods, and silt deposition. For instance, in the Rift Valley and Mbagathi Riverine Dispersal Corridor in Kenya, inappropriately located embankments and underpasses of the SGR obstruct water courses [3]. Moreover, development corridors can diminish access to water, particularly during periods of drought [3,4]. The inadequate planning for water can result in artificial water scarcity, which can be exacerbated or alleviated by climate change impacts [47,50,68,69]. [45][49,50][50][70]

4.Discussion

4.1. Exploring solutions to challenges

Development planners need to look beyond the development of corridor mega-infrastructure and towards a more interconnected set of policies, programmes, and plans [1,8,25], that account for local complexities and prevent spillover of impacts [3,4,18,19,53]. Solutions that planners and implementers can use to address the eight issues outlined above are explored below.

Impact assessment processes: Systematically and consistently following impact assessment (i.e., EIA, SEA) regulations is the most direct way to start addressing social-ecological issues resulting from poor planning (challenge 3.1.) [7]. However, best practice in impact assessment is generally not followed [6] in some cases because of lack of capacity to effectively implement regulations and in other because projects are fast-tracked for political

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and economic reasons [18, 19, 33]. Addressing challenges 3.2 (Planning coherence) and 3.3 (Effective Governance) is fundamental to improve these processes. Moreover, to be more effective, impact assessment tools need to be applied on the ground and follow the impact assessment project cycle [6,7]. Participatory planning approaches have been developed [53] and are particularly useful to bring differing agendas together, for example discussions between different Ministries in the same country (challenge 3.3). To achieve this, user-friendly and participatory approaches are available to envision and monitor development trade-offs and synergies, for example, applying Q-Methodology [8]. This methodology supports a systems view of development interactions at various stages in development corridors evolution: from design and conception, to monitoring, decommissioning. It offers a participatory tool to explore possible outcomes and iterate strategies. Another tool developed for local scenario development and implementation [71] has been used in the SGR and Kilombero Cluster of SAGCOT [2]. The “KESHO” (meaning ‘tomorrow’ in Swahili) tool tuilizes the ‘lens of land use change’ to chart the potential land use futures in 2030 and 2063, to resonate with the SDGs and African Union Agenda 2063. The potential land use futures and their impact on ecosystem services [72] are ultimately driven by the views of local participants. “KESHO” can also help to predict water and biodiversity futures, as well as agricultural expansion, which can then inform plans to manage potential changes [72,73].

Coherence across international, national, and local planning: Development corridors typically mobilise through a series of investments, programmes, projects and institutions that interact and develop incrementally within a corridor landscape. Experiences from Kenya reveal a gap between international donor commitments, national strategies and enforcement on the ground, which is sometimes misaligned with local needs. To ensure coherence across international agreements (challenge 3.2.), corridor planners need to consider how their plans will assist or challenge commitments already made by the countries through for example, the SDGs, the UNFCCC, UNCCD, the CBD Kunming, more specifically the

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Montreal Global Biodiversity Framework and the 23 targets to be met by 2030, among others. Very often, these existing commitments are ignored when corridors are planned. At the same time, corridor planners also often ignore national development and conservation plans developed by other parts of government. Major actors with the power to make changes should take leadership and lead the efforts to meet these commitments. These are ministries and Office of the President of recipient countries and financiers from investor countries. The latter set, often very different environmental and social, standards, that contractors tend to only follow through work plans and timelines in contracts they do not have much power to influence. National and local level governments are important for ensuring that large-scale public or private investment is accountable to sustainable development agendas. They are also essential for providing services, like water and affordable housing, to marginalised communities. Cross-sectoral coordination is therefore needed, for example, between ministries and Office of the President.

Effective governance: To overcome currently fragmented and siloed corridor governance and management systems that limit holistic management of development trade-offs (challenges 3.3.), leadership needs to be championed at a high-level (i.e., Office of the President). Coordination should be accompanied by investments in institutional and policy environments [74–76]. For example, creating inter-ministerial and multi-stakeholder corridor fora to discuss key issues and share experiences, although these are likely to require enhancing and resourcing [1,8,25,77]. Opportunities exist to enhance or embed multi-stakeholder partnership processes, such as through regular meetings and working groups that operate in local languages to build decentralised cooperation, strengthen local negotiation capacities, build institutional memory and transfer knowledge internationally in the face of growing resource constraints. Meanwhile, the private sector can develop inclusive branding, promote reputation, and thus increase financial ratings [54]. Forging such partnerships will harness development synergies and address the barriers that prevent

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marginalised populations from participating in and benefitting from current corridor investments [1,77].

Consideration of inclusivity and equality: Participatory planning is essential to ensure better consideration of inclusivity and equality (challenges 3.4 and 3.5). Participatory scenario planning, for example, brings together diverse stakeholders to develop a range of robust and flexible policies or investment strategies that will function in a variety of future contexts [78–80]. Rather than forecasting the 'most likely' future or predicting a single or most probable outcome [81], scenario planning considers the potential effects of multiple future stressors [79,82]. Scenarios have been shown to bring an array of stakeholder voices together and help decision-makers adapt their strategic beliefs. They also help stakeholders to notice, assess and respond to change [83]. For example, divergent scenarios of future land cover change were developed to explore potential futures of corridor developments in 2030 and 2063, to resonate with the SDGs and African Union Agenda [53]. Scenarios were developed in the SAGCOT cluster of Kilombero in South West Tanzania, and along the SGR running from Mombasa up to Kisumu, in Southern Kenya. Additionally, trainer-of-trainer modules were developed, and workshops were conducted to teach practitioners to apply scenario planning tools in the UK, Tanzania and Kenya.

To address the issue of development corridors not facilitating inclusive and equal economic opportunities for all, development planners need to look beyond the development of corridor mega-infrastructure and towards a more interconnected set of policies, programmes and initiatives. These can harness development synergies and address the barriers that prevent marginalised populations from participating in and benefitting from current corridor investments. Strategic partnerships that coordinate public and private agricultural investments, develop soft as well as hard infrastructure, and overcome barriers to investment, could play a key role in upscaling the inclusion of small enterprises in corridors and these should be more actively integrated into corridor design. Research [77] shows that

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multi-stakeholder partnerships (MSPs) can play in supporting small enterprises in Africa to grow and to adapt to climate change. MSPs are collaborative arrangements between public, private and civil society sectors, often built on the same philosophy as that underpinning the concept of the corridors: of mobilising the private sector in development action.

Impacts on biodiversity and ecosystem services: Regarding overlooked impacts on biodiversity (challenge 3.6), best practice guidance for biodiversity mitigation planning is widely available [e.g., [7,84,85]] and should be applied across infrastructure corridors currently underway or being planned. This includes following long term established biodiversity mitigation frameworks (e.g., the mitigation hierarchy) [85] and adhering to international best practices in biodiversity mitigation (e.g., the International Finance Corporation Standard 6) [86]. Through DCP, we showed how planning for the maintenance of biodiversity values in development corridors can consider ecological connectivity [58], animal movements [35] and biodiversity values [6]. Moreover, analyses have explored solutions to better understand risks and benefits in infrastructure projects in 137 countries [87] and in clusters within the SAGCOT. Climate risks should also be included in the project's appraisal process so that mitigation plans (e.g., meaningful local community engagements) can be developed [54].

Ecosystems and species provide ecosystem services for people, many of whom, especially in Africa, are dependent on nature for their livelihoods. In East Africa key ecosystems include mountain forests and wetlands for hydrological regulation, areas designated for wildlife for their tourism or hunting revenues, or natural woodlands for pollination, timber, firewood and charcoal production. Tools that integrate ecosystem services and biodiversity can inform both policy and land use decision-making [88,89]. For example, land use change modelling tools such as, CLUE-S [90], biodiversity intactness models [91] and ecosystem service modelling tools SPHY [92] and InVEST [93] have been used to assess potential

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impacts of planned developments on ecosystem service delivery and biodiversity in the Kilombero and Ihemi clusters in the SAGCOT corridor. More importantly, in addition to detailed local analyses that the DCP project undertook, areas of global biodiversity importance are well mapped within countries and globally (e.g., Key Biodiversity Areas database [94], IUCN red list of threatened species [95], or biodiversity relevant data hosted at UN Biodiversity Lab [96]). These critical areas for conservation should be considered in development corridor plans to avoid unintended harm. Infrastructure development that integrates these values - framed in terms of nature-based infrastructure - can help deliver more SDGs targets than built infrastructure alone [97].

Incorporation of future climate risks: Corridor planners need to consider climate change mitigation and adaptation strategies to manage these potential impacts (challenge 3.7). For example, a climate risk assessment for the Rufiji River Basin that overlies much of the SACGOT development corridor [49,50] was led by DCP. It involved developing an understanding of the basin and the key decisions being made across interdependent sectors such as water-energy-food. It also included identifying what is important for stakeholders and how they assess benefits, listing options that achieve enhanced and more sustainable development benefits [50]. Future climate projections for the Rufiji River basin show continued warming (0.8 °C to 1.8 °C by the 2040s) and mixed patterns of change in future rainfall. Modelled changes in Rufiji stream flow range from approximately -30% to over +60%. Contingency plans for water management under stresses of climate change (addressing irrigation, hydropower and environmental needs) should include modified operating procedures for existing and planned hydropower infrastructure and water allocation under both drier and wetter conditions. This should occur alongside development of a multi-agency drought management plan for seasonal and interannual events. As impacts are cross-cutting, multi-agency coordination is going to be vital for both long-term planning and for shorter-term decisions, such as drought management. High level dialogue to this effect should be encouraged. Increases in the productivity of land and water via

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improved irrigation schemes and consideration of financial incentives for farmers. Especially water saving technologies, to adopt new measures should also be considered [70].

Integrated water resource management: Finally, integrated water resource management should become a fundamental building block of all corridor plans (challenge 8). Hydrological models have been developed for several river basins in East Africa. These include the Rufiji [46,64,98], and little Ruaha Basins in Tanzania [48] and the SGR region in Kenya [3]. These hydrological models can be used to provide advice to those planning agricultural development, urban development, hydropower facilities, wildlife reserves and other water uses. Models show reduced water availability in the dry season in East Africa, a significant constraint for development planning at the basin scale. Careful planning of water uses and consideration of the impacts of climate change on water resources will be required across the whole region into the future, with guidance for the SAGCOT corridor in Tanzania already published [64].

4.3. Using available tools and guidance materials.

Materials are already available to assist corridor planners, funders and implementers (e.g., [28,99,100]) to implement the solutions explored above. DCP has developed a source book on best practice and common failings in EIAs and SEAs as applied to development corridors [7]. This book contains 15 case studies across Asia, Africa and Latin America, with two chapters on lessons learnt. An e-learning course structured around the four stages of the creation of a development corridor has also been created to help development corridor practitioners available on the UNDP Learning for Nature website [101]). This course outlines considerations for corridor planners (module 1), presents several existing tools that can help screen projects for biodiversity, carbon, ecosystem services and social risks (module 2) and the issues financiers need to consider (module 3). The modules show that existing tools, such as the Integrated Biodiversity Assessment Toolkit (IBAT) [102] and Exploring Natural

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Capital Opportunities, Risks and Exposure (ENCORE) [103], can be used for screening in the pre-proposal and planning stages of a development corridor.

In addition, a UNEP report [87] investigates the environmental risks and socio-economic benefits of planned road and rail transport infrastructure projects underway or planned in 137 countries. The report is accompanied by an online interactive viewer tool, the Global Infrastructure Impact Viewer [104], which displays on a global map that attributes values to projects' risks and benefits. International Good Practice Principles for Sustainable Infrastructure [28] and a business brief on future-proofing infrastructure [54] have been developed by UNEP for global use and can be applied to development corridor planning.

Guidance for businesses to report on and address risks and dependencies on nature are being produced by groups such as the Task Force for Nature Related Financial Disclosures (TNFD) [105] or the Science Based Targets Network. The TNFD framework, responds to a general increased pressure from global society on disclosing nature-related risks and opportunities in business operations. Understanding how these might affect project/investments and stakeholders, creates greater transparency and accountability. These kinds of guidance may facilitate systemic changes across business, which could leverage significant positive impacts.

4. Conclusions and recommendations

Four years of DCP findings in East Africa supported by other relevant research on development corridors have been summarised intro eight key challenges the current corridor paradigm is facing. Solutions to these challenges exist and generally involve applying international best practice on social and environmental impact assessment, ensuring greater transparency, accountability, and coordination at subnational, national, and transnational levels and for all stakeholders involved in the process. Implementing the solutions entails

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meaningful consultation with local communities as early as possible in the project cycle, transparency in contract negotiations with recipients of funding, as well as full implementation and monitoring of mitigation measures agreed in the impact assessment process.

Table 1 presents a summary of how we might link the challenges with the solutions explored above to specific recommendations for key stakeholders. The stakeholder groups are primarily: 1) Impact assessment practitioners: technical experts who work on EIA and SEAs who need to use best available knowledge and guidance developed by UN agencies, NGOs, and business facing networks and initiatives (e.g., SBTN, TNFD); 2) Government: relevant agencies or parastatal entities need to coordinate work across Ministries, ensure that existing commitments and local regulations are followed and implemented, and that development that does not damage the environment or disadvantage groups; 3) Funders: those who finance development corridors need to ensure that their funds are supporting sustainable development and not harming nature or local people; and 4) Contractors: actors physically constructing the infrastructure need to ensure that the work they are doing is aligned with mitigation measures developed through the impact assessment process, working hand-in-hand with local government and communities.

By adopting these recommendations, the design, implementation and running of development corridors can better realise their development potential, maximise investment, and minimise unintended consequences for the greater good of African nations, its people, wildlife and ecosystems.

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618 **Table 1. Eight challenges in the current development corridor model and recommendations for key stakeholder groups.**

Challenges	Description/potential consequences	Recommendations for stakeholders
Impact assessment processes	Poor application of existing best practice guidance in development corridors results in poorer outcomes for people and nature.	• Impact assessment practitioners to follow best practice guidance in impact assessment such as for example full consideration of the mitigation hierarchy or emerging frameworks such as the Science Based Targets for Nature guidance (SBTN), • Government to create expert-led steering groups from a range of often siloed ministries, working together to deliver better outcomes. • Government, funders, and contractors to use information about priority areas for conservation in the infrastructures contract negotiation processes and to ensure meaningful inclusion of local and indigenous peoples in the decision-making process. • Funders, companies, and contractors to disclose impacts following emerging frameworks (e.g., TNFD).
Coherence across international, national, and local planning	Poorly-integrated planning across sectors and scales generates unintended cumulative impacts.	• Impact assessment practitioners to undertake background research in partnership with government on international targets and national commitments to ensure that corridor plans and implementation aligns with national agreements for the UN Conventions on Biological Diversity, Climate, Wetlands, Wildlife Trade, Desertification, and the SDGs. • Government and funders to integrate local needs and requirements when planning or designing and approving large-scale infrastructure investments. • Government and funders to strengthen assessment of SDG co-benefits when designing infrastructure investments and seek to align with SDG standards across investors, donors and recipient countries. • Governments to facilitate building partnerships between companies involved in implementing infrastructure investments and local stakeholders to help better understanding of best practices and sharing of experiences.
Effective governance	Fragmented and non-inclusive governance hinders effective implementation.	• Governments to lead cross-sectoral coordination needs by championing it at a high level (i.e. Office of the President), investing in institutional and policy environments, and building decentralised cooperation and strengthen local negotiation capacities. • Funders and contractors to develop inclusive branding, promote reputation and increase financial ratings.
Consideration of inclusivity	Historically marginalised communities are not meaningfully consulted about corridor development planning, implementation, and functioning.	• Government and funders to ensure alignment of international donor commitments, national strategies, and implementation supporting with local needs. • Impacts assessment practitioners, governments, and funders to pursue greater integration of local needs is required when planning or designing large scale infrastructure investments,

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Consideration of equality	Development corridors tend to benefit already privileged socio-economic groups rather than helping improve the lives of more vulnerable groups.	• Impact assessment practitioners, governments, and funders to carefully consider the potential outcomes of development corridors for people at all stages. • All stakeholders to ensure that planning stages incorporate the needs of rural, poorer communities to align with national and SDG targets.
Impacts on biodiversity and ecosystem services	Corridor planning does not follow best practice to identify ecological or ecosystem service impacts or implement appropriate avoidance and mitigation measures.	• All stakeholders to consider the existing values of the landscape for nature conservation and the delivery of ecosystem services to poor people. • Impact assessment practitioners to use available tools and data to include the direct benefits of ecosystem services in corridor development plans. • Government, funders, and contractors to ensure that ecosystem services provision to poor people is maintained or enhanced.
Incorporation of future climate risks	Corridors are not integrating climate or land use change risks and projections in their planning and implementation.	• All stakeholders to consider the potential positive and negative future impacts of corridors on local populations, land use, and economic growth through collaborative scenario planning. • Impact assessment practitioners to assess impacts of infrastructure development on habitat integrity, ecological processes, and ecological connectivity across the landscape and ensure these are reflected in implementation plans. • All stakeholders to mitigate potential disasters that will negatively impact people and the infrastructure, such as floods and droughts created by the interaction of the new development with climate change.
Integrated water resource management	Projects associated with development corridors do not fully consider adverse impacts on water quality, water quantity as well as on water supply and demand.	• Governments and impact assessment practitioners to develop contingency plans for water management under stresses of climate change (addressing irrigation, hydropower and environmental needs). • Governments to promote high-level dialogues for the development of a multi-agency drought management plans for seasonal and interannual events.

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Supplementary Data: List of outputs from the Development Partnership project

An excel spreadsheet with all DCP outputs listed and categorised can be found here: Supplementary data 1.xlsx

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