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ABSTRACT

The Suez Canal connects the Red Sea with the Mediterranean and shortens the passage between Asia to Europe from previously 24 to 16 days. Constructed in the second half of the 19th century as a ditch canal, it cuts through the Isthmus of Suez as one of the most highly frequented shipping routes globally and an important source of foreign currency revenue for the Egyptian state. It has brought forth multiple generations of cities: Suez, Ismailia and Port Said in the 19th century, Port Fouad in the 20th and New Suez and New Ismailia in the 21st century. With a population increase of currently roughly 1 million new inhabitants every 10 months and a loss of agricultural land due to urbanization of the Nile Valley, the governmental agenda since the 1970s has been to move away from the Nile to urbanize the desert in varying degrees in combination with industrial development and decoupled land reclamation. Global push-and-pull factors around the Suez Canal inform a discussion around how this large-scale infrastructure aligns with a legacy of the megaproject within the Egyptian context, how colonization around it links to the national urban development agenda, and thirdly, the socio-ecological challenges and potentials related to its current reliance on an industrial logic. The assessment of various risks pertaining to the Suez Canal Development, e.g. climate change, is the first step in identifying potential resilience measures to mitigate adverse impacts on the Suez Canal region's potential trans-industrial future.

Getting Our Cities Right? The Suez Canal – Advocating for a Plan B

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Suez Canal; Trans-industrial; Socio-ecological; Resilience; Path dependencies; Climate change

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Introduction

The Suez Canal – Path Dependencies, Global Forces, Local Pressures

Our inability to transform our extractive and growth reliant economies and thus our ecological footprint into a positive one is becoming increasingly existential. Differing and potentially conflicting systemic boundaries between economies and ecosystems (Capra & Jakobsen, 2017) in combination with path dependencies may be considered as the forces that generate this inability. This specifically applies to the spatial consequences of shipping channels. As large-scale infrastructures, their demand for investment in maintenance and expansion in relation to revenues remains a constant race (SCA, CAPMAS 2016). Yet, our approaches rely on continuous economic growth enabled by a continuous increase in national debts. The Suez Canal and its progressive expansion mirror this logic. Since 1869, the Suez Canal connects the Red Sea with the Mediterranean by cutting through the Isthmus of Suez shortening the passage between Asia and Europe from previously 24 days (Cape Route) to just 16 days and currently accommodating 12% of global transshipment. This makes it one of the most significant shipping canals in the world. Only recently has the blockage of the canal through the MC Ever Given shown the potential fragility and global economic implications of its malfunctioning (Masters, 2021). Uncertainties evoked by geopolitical instability and climate change consequently exacerbate the given risk of failure to perform.

Geo-economic interdependencies involving resource availability, labour costs, know-how, hard currency and not lastly economies of scale make the Suez Canal strategically indispensable for given global transhipment routes. From a European perspective, this implies multiple reliances. For one, industrial production and manufacturing in and consequently importing goods from South-East Asia. On the other, energy provision through external resources that are currently transitioning from oil to hydrogen and will be produced by renewable energy powered by the sun and wind in the desert of the MENA region (Häusler, 2022).

For the Egyptian state, the canal's sole country of passage, the Suez Canal, together with tourism and remittances of Egyptians working abroad, serves as main sources of foreign revenue. According to The Economist, Egypt's external debt has increased to more than 40 % (compared to 17% in 2013), it has floated its currency three times since 2022 and its population is struggling to afford food prices that have increased by 70% in the past year. The risks the Suez Canal Zone and its further development face are cross-sectoral and multi-scalar covering economic, social, and increasingly environmental realms. An increase in the population of roughly one million new inhabitants every 10 months (CAPMAS, 2023), severe issues related to water scarcity (UNICEF, 2021), rapid urbanization both formally and informally (GIZ, 2019; Keeton & Provoost, 2019), climate change (Pörtner, 2022), the reliance on and a lack of foreign currency, the war in Ukraine with its impact on wheat provision, recurring military conflicts on all borders, as well as the fear of terrorism in the region are challenging Egypt socially, economically, and increasingly ecologically. Its international loans forced to comply with the IMF and other international creditors' conditions only recently led to the repeated floating of the Egyptian pound (IMF, 2022) and the demand for a new IMF loan to avoid bankruptcy (Abdel Fattah, 2022). In this complex of predominantly economic urgencies, Egypt's vulnerability to climate change and overall socio-ecological challenges, but also potentials are, as of yet, not sufficiently taken into account (Abou-Ali, El-Ayouti, & Mohieldin, 2023).

With the Suez Canal Development, largely representative for our questionable global response to our race against time, the Egyptian State remains path-dependent of the industrial logic of the megaproject– even when it comes to achieve the so-called green transition. Uncertainties are not taken into account and therefore the development lacks contingency and resilience. From an urban planning and architectural point of view, we would like to bring forward the hypothesis that this path demands for a complementary strategy that can increase the self-sufficiency of urban communities in the context of the risks inherent in the Egyptian megaproject.

Methodology

Given existing push-and-pull factors, we explore industrial path dependencies through a contextualization of the Suez Canal within Egypt's legacy of megaproject approaches including its top-down, market-steered urbanization. Responsive to the urgent need of "Getting our Cities Right", quoting Maimunah Mohd Sharif, potential strategies and a Plan B for the built environment is brought forward. To give context to the diverse risks the Suez Canal Zone as an industrial and urban development corridor is facing, an analysis inspired by the Dutch layer model as a comparative spatio-temporal framework and tool of analysis (Schaick & Klaasen, 2011) is applied to describe the region and its development over time. It outlines historical and projected developments in relation to inherent risks. Accordingly, landscape and climate conditions, infrastructural networks, urban and industrial development, and metabolic flows of goods, people, and other creatures that inhabit and traverse the canal and its surroundings are explored. Results inform a discussion around how landscape-based, no-regret solutions within the built environment can increase resilience as this large-scale infrastructure aligning with a legacy of the megaproject and its inherent industrial logic can be questioned, but hardly changed.

The Legacy of the Megaproject

By introducing "new puzzles to the field of Middle Eastern history concerning large-scale infrastructures, energy systems, the multinational corporation, state formation and empire, techno-scientific expertise, and democracy" (Shafiee, 2019 referencing Mitchell a.o), the Suez Canal with its radical landscape configuration and paternalist history can be considered a socio-cultural object. It aligns with a long Egyptian legacy of megaprojects that identify with a singular, male leader driving both their own legacy and triggering national pride and identity through these developments. For Egypt's current president, Abd El Fattah El-Sisi, the New Suez Canal, a nationally financed bypass to the existing canal implemented in 2014-15 (with a further expansion planned), and cumulatively the urban-industrial complex of the Suez Canal Zone, the New Administrative Capital, and multiple new city foundations prevalently in the desert (as part of the so-called fourth generation of New Urban Communities), massive road development, large-scale desert agriculture, and the mining of gold, copper, iron, phosphate, and other minerals all aim to diversify sources of income (Waly, Rizk, Werr, & Lewis, 2023).

Egypt has a long history of mega projects spanning from the Pyramids to the New Suez Canal and has brought forward paternalist, top-down narratives. The ability to implement these projects through internal and/or external technological and economical means and mass labour is part of the collective pharaonic, colonial, and postcolonial identity of the country as a hydraulic culture under the paradigm of large-scale landscape transformations. The Suez Canal, built in just ten years, was followed by the construction of the Aswan Low Dam by the British (1906) and, more significantly, the High Dam in the 1960s under Gamal Abdel Nasser. Its construction disconnected the Egyptian Nile from its tributaries and rich sources of silt that, during no longer occurring floods, had for millennia enabled the tremendous fertility of the Nile Valley and Egypt's self-sufficiency and wealth. It led to the decline of food sovereignty and eventually made Egypt the world's largest wheat importer to date. It also led to the flooding of Nubian land, and with that, the displacement of its people. With the Aswan High Dam, Egypt has radically transformed its

landscape from self-providing to an industrial agricultural system. This has created detrimental path dependencies in relation to further landscape exploitation and external reliance that also the current Suez Canal Development reflects. Exacerbating existing pressures, the Nile as Egypt's primary water source, is currently compromised by the filling of the Grand Ethiopian Renaissance dam.

With a loss of agricultural land due to the previous urbanization of the Nile Valley (Sims, 2010; Sims, 2018), the governmental agenda since the 1980s has been to move away from the Nile by building new satellite cities in the desert. The New Administrative Capital, planned to accommodate 6.5 million inhabitants, changes the orientation of these developments parallel to the Nile to expand eastward thus giving the canal a new degree of centrality (Figure 1).

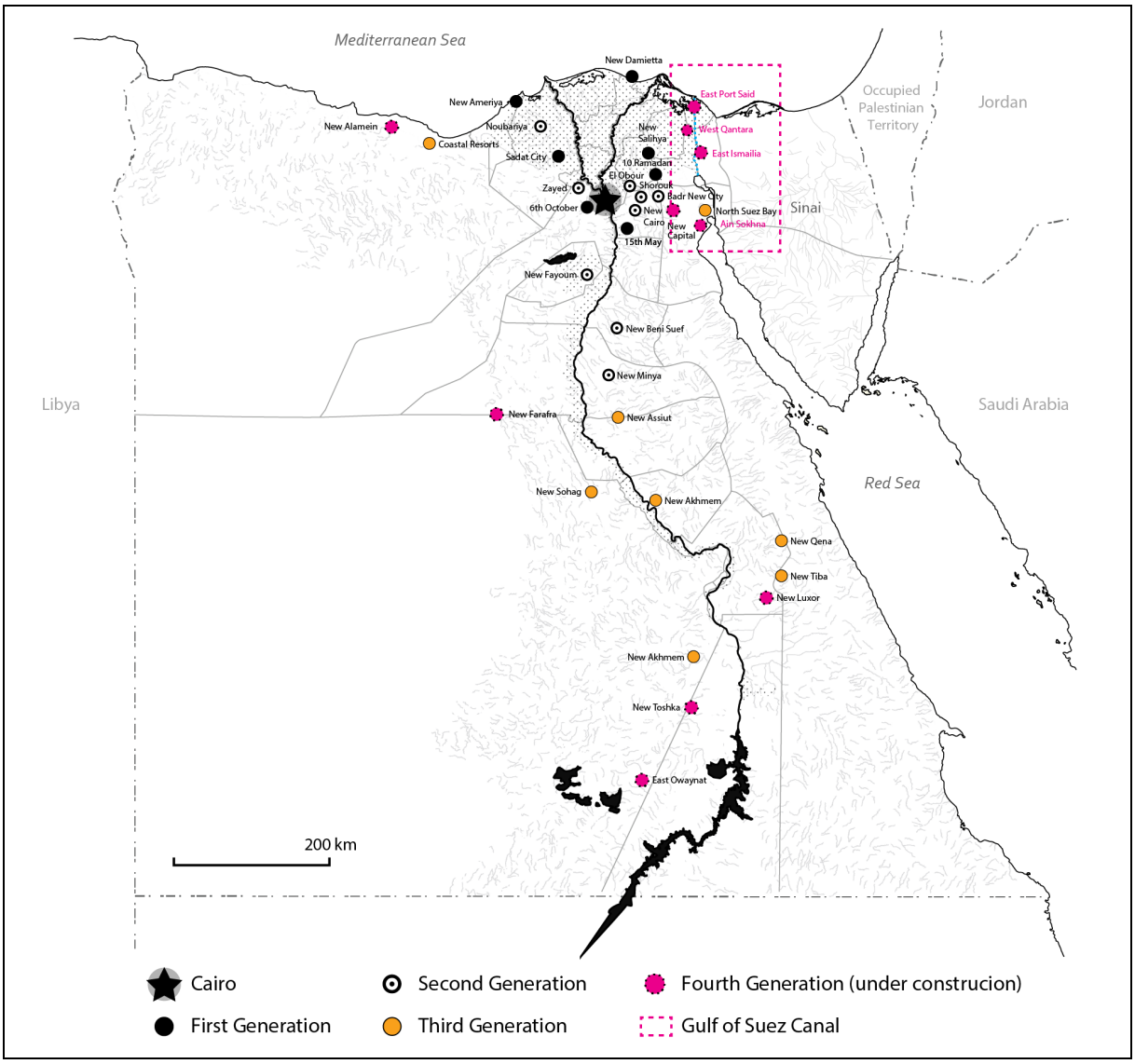

Figure 1. Egypt's Wadis, New Urban Communities, and the Suez Canal Development Area. (Graphics: -anonymized for peer-review- adapted from NUCA, 2023).

Historically, the Suez Canal was part of an orientation toward Europe celebrating the advent of a new era by Ismail Pasha, Khedive of Egypt at the time, and Ferdinand Lesseps, the French engineer in charge of its execution. The decline of the Ottoman Empire and the advent of debt to European banks eventually led to the handover of Egyptian shares to the British. The end of Britain's rule of Egypt was celebrated with Nasser's successful nationalization of the Suez Canal in 1956 followed by Anwar Sadat's plans to create an economic zone through the Suez Canal Development Plan

incentivizing further international activity as part of his Open-Door policy Infitah. This was challenged by the halt of transhipment caused by the Egypt-Israeli War under his reign between 1967-1975 (SCA). Following the Port Fouad port development under Hosny Mubarak in the late 90s, this project was again put on hold due to continued political instability through the Arab Spring and the short era of the democratically elected Muslim Brotherhood.

In 2014, the current president Abd El Fattah El-Sisi not only proclaimed his plans to build a second channel to increase transhipment but embedded this nationally funded endeavour in bringing back the larger regional development plan. The Suez Canal Zone (SCZONE) is an area of 461 km2 with four new Industrial Zones in Sokhna, East Port Said, Qantara West, Ismailia East (Technology Valley), and six-port developments: Sokhna, Al Arabiya, East Port Said, West Port Said, Al-Arish, and Al-Tor. The general authority with "executive/regulative powers that adopts an investor-friendly business environment (..) for national development plans" runs under the same name. As part of the fourth generation of New Urban Communities aiming to redirect urban growth away from the Nile Valley and Cairo; Port Said, New Ismailia, and New Suez focus on the provision of housing linked to expected job creation. A new chapter in this sequel of industrialization may be expected with the planned hydrogen transition (Häusler, 2022). While the sheer magnitude of projects and timelines that also the Suez Canal Development is a part of are more than impressive, critical voices question national ambition in relation to the severe economic and environmental pressures, and inherent risks for the country and its people.

Getting Our Cities Right - the Need for a Socio-Ecological Perspective

"Getting our Cities Right" refers to the specific vulnerability of the urban realm in its provision of livelihoods, potential economic and environmental impacts, i.e. climate impacts, specifically for developing countries, and accordingly, the need to become more resilient in line with the New Urban Agenda (UN-Habitat, 2022). Vice versa, it includes the question of the ecological footprint cities produce. Applying this to the Egyptian context of the New Urban Communities program driving formal planning since its first generation of cities in the early 1980s, and in consequence of its diverse shortcomings their informal response, shows a.o. a missing socio-ecological perspective in planning (Sims, 2010; Visser, MED-ENEC, & Yeretzian, 2013). We claim that a socio-ecological perspective demands consideration of the regional scale where larger landscapes, in this case, the desert, the delta, and the seas, need to be given a different value in their ability to provide non-monetary ecosystemic services while buildings and their inhabitants need to change their negative ecological footprint into a positive one by becoming producers instead of consumers. This could enable a multi-scalar and multi-functional approach that accumulatively increases resilience. The support of livelihoods through additional sources of income and increasing self-sufficiency in terms of food, water, and energy provision, could be coupled to relieving pressure on increasingly vulnerable centralized infrastructures and thus raising overall resilience in case of their failure or even absence, while improving the environmental impact of cities.

According to the Global Risks Report 2022 "Appreciating systemic vulnerabilities and embracing a diversity of approaches can help leaders build better resilience" (WEForum, 2022). This raises the question: Can the Suez Canal, as an extractive, economically and growth-driven, supra-regional development corridor and a bottleneck for international transhipment synergize its modernist and geopolitically so transformative manifestation, its aligning infrastructure, industries, and top-down urban development with urgent socio-ecological concerns? How adapted and accommodating will these be? Looking at the legacy of four generations of new urban communities and their given pace of accelerated execution do not show a learning model. Instead, one may assume that the new urban developments along the canal will follow the current commodified model of development that lacks to take the capacity of the built environment in terms of CO2 reductions, waters-sensitivity, regeneration and self-sufficiency into consideration.

In this article, we identify the risks that can hinder the achievement of expected benefits of urban and regional growth linked to the Suez Canal and the aligning port and industrial hub expansions in order to advocate for a Plan B. As potential failures are not considered, given risks produce a lack of resilience. In this way, the Suez Canal Region may be exemplary for other industrial development corridors globally that are planned top-down. Uncertainties, multiple risk areas, and given risk density demand a planning strategy that considers a more holistic approach to potentially make developments safe-to-fail. Beyond policy recommendations, what spatial solutions could increase resilience for this specific socio-ecological context, and given the current lack of data availability, what research recommendations can be formulated?

By enabling regions to become more self-sufficient, and thus more resilient, a secondary agenda is needed: A plan B that produces both monetary and non-monetary ecosystemic benefits given the current development and, in case of its failure, a potential backup plan. Circular, landscape-based solutions for the built environment around the water-energy-food nexus may incrementally have a positive systemic impact. While being applicable across all societal realms, they offer low-tech, low-cost and low-maintenance models capable to cater to the most fragile parts of society. They can buffer increasingly vulnerable, larger infrastructures while positively influencing the ecological footprint of our built environment and offering livelihood. In this way, potentially small-scale, landscape-based solutions provide bottom-up, no-regret approaches within the context of megaprojects and their uncertain success as those involved tend to underestimate costs, overestimate revenues, undervalue environmental impact, and overvalue economic development effects (Flyvbjerg, Bruzelius, Rothengatter, 2003). In the case of the Suez Canal those driving the megaprojects both politically and economically being the Egyptian Armed Forces.

The Suez Canal Zone's new cities and industrial hubs as described on the governmental site continues to primarily outline new developments through quantitative parameters such as proximity to infrastructure nodes, number of jobs, housing units, sqm, etc. (Presidency EG, 2023). They do not give insight into a critical reflection on the above or a learning model and thus allow us to question a change in strategy from previous new urban foundations in the desert when it comes to development around the canal.

The potential risk of a canal closure and consequently the economic impact thereof as well as the multifaceted geopolitical push-and-pull factors show how vulnerable the reliance on the Suez Canal as the primary driver for all industries is, thus providing more arguments to create alternative agendas that are not directly linked to it. Beyond the permanent rural and urban population, there is a seasonal workforce and of course the crews of the cargo ships. In order to encourage permanent residencies instead of a local migrant working culture a diversification of the given urban agenda may be productive. To increase the resilience of the Suez Canal region through architecture and urban planning and design, we advocate for a complementary socio-ecologically driven development agenda exemplarily outlined as follows:

With every new urban foundation, we have the chance to consider wind, topography, and orientation to design an energy-efficient urban layout (Visser, MED-ENEC, & Yeretzian, 2013). Wadis may produce catchments at the macro- and micro-scale to mitigate water scarcity, to cultivate food and to green the desert (Malek, 2020, Kresh 2020). Desert Forestation irrigated with treated wastewater may produce a local timber industry while improving microclimates for the urban development that provides the nutrient-rich wastewater (El Kateb et al, 2015). Historical urban layouts provide natural ventilation by accelerating air flows through pressure difference (Dabaieh, 2011). Above all, regenerative urban models allow us to create a city of proximities that is pedestrian and cycling-friendly and adds to a better climate, spatial justice, health, and safety.

Buildings can themselves become productive to increase overall resilience and more specifically self-sufficiency regarding the water-energy-food nexus by integrating small-scale, nature-based solutions (Redeker & Jüttner, 2020). Understanding the city as a host to (partially) site-independent

solutions where buildings accommodate green roofs and facades to grow food (creating a source of income), collect and potentially treat water, insulate the building, create better microclimates, while buffering centralized systems. This strategy may be applied to new as well as retrofitting existing buildings to collectively provide a systemic impact. Passive architectural principles on the building scale work with orientation, materiality, thermal mass, natural ventilation, the albedo effect, window openings, and kinetic shading systems to reduce energy demand and increase overall thermal comfort. To avoid further vacancies, floor plans can become more flexible and multifunctional to accommodate small businesses and multi-generational living. Models for this have been developed at the Ministry of Housing at the beginning of the 2000s (Shehayeb, 2011). All of these approaches are possible to integrate with existing urban development plans for the Suez Canal Zone to increase resilience by offering no-regret solutions at a low cost. The knowledge is readily available to be adapted to the specific context.

Landscape, Water, and Climate Conditions and Habitat

Egypt's landscape is defined by the Nile Valley, its Delta, the surrounding desert, and by the coastlines of the Red Sea and the Mediterranean. The topography is shaped by wadis that discharge into the Nile or the seas (Figure 1). The arid climate with very limited, but extreme rainfalls makes the country reliant on the increasingly contested Nile for freshwater. In combination with the rapid population increase, this has put the country in a state of water scarcity with less than 500 m3/capita/year (see Redeker & Jüttner, 2020). Since ancient times, Egypt's wadi landscape has been overwritten with man-made irrigation and drainage canals diverting from the Nile and, to a large extent, discharging into the lakes and lagoons, today totalling more than 10,000 km in length (Sampsell, 2014). Wadi Tumilat is a 50 km-long cultivated valley, leading from Abassa to Ismailia. To provide drinking water for the workers during the construction of the Suez Canal, a Nile canal was dug along Wadi Tumilat. It provides Ismailia, the main city during construction, with fresh water until today. To mitigate dependence on the increasingly contested Nile waters to ensure fresh water supply, two desalination plants are being implemented. Concerning freshwater, they are producing 1.5 times the amount of brine water that is pumped out to the sea and further negatively impacting ecosystems. Studies show risks of waterlogging, salinization, and land subsidence partially caused by past informal urban development, and irrigation of reclaimed agricultural land to the East of the delta. This threatens parts of Ismailia and demands for water drainage management (Moheb, 2015). In East Ismailia an increase in soil salinity due to seawater seepage from the canal (Figure 2), as well as droughts further impacted by climate change risk food production demanding "adaptation measures to climate change in the agricultural sector" (Elwan, 2021).

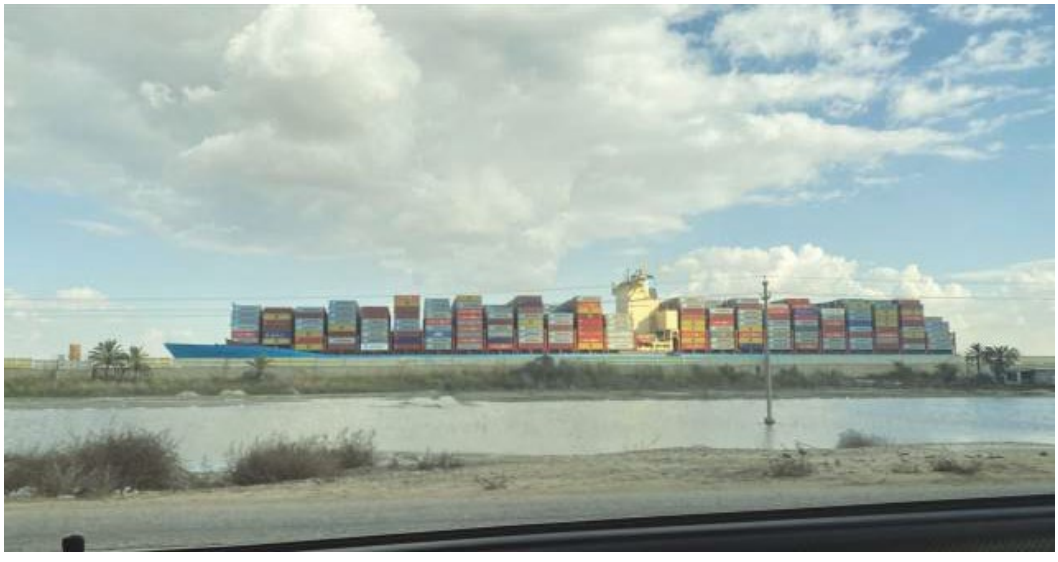

Figure 2. Container ship, Canal, and seepage. (Photo: anonymized for peer-review).

The Isthmus of Suez East of the Nile Delta separates Egypt's mainland from the Asian continent and the mountainous desert of Sinai. It includes three shallow water-filled depressions: the Bitter Lakes, Lake Timsah, and, making up the outer fan of the Nile delta and aligning the Suez Canal, Lake Manzala. All lakes' degree of salinity and thus biota has been influenced by engineering measures. Before the canal was built, the Bitter Lake was a freshwater lake fed by a Nile distributary. It may play a strategic role in the future when it comes to forming a barrier of freshwater or hyper salinity to interrupt the increasing passage of non-indigenous species. The land has been reclaimed both in the desert to the south of the deltaic fan, but also large parts of Lake Manzala have been laid dry to expand agricultural production which has proven far less productive than expected see (Shoman, 2019). Blue-green infrastructure in the form of constructed wetlands along the southern shore of Lake Manzala treats 25,000 cubic meters of water polluted from the Al Bahr El Baqar drain (Redeker & Jüttner, 2020). The area around the Suez Canal with its lakes is a vital link for many birds to cross the Sinai Peninsula and the Arabian Desert and an important stopover site for migratory birds on their way to their wintering grounds. It also poses a danger due to industrial and residential areas along the banks and collisions with vessels. Lake Manzala is the largest saltwater lake in the country and a vital ecosystem. Its wetlands have played a crucial role in providing habitat for a wide variety of birds. Many people depend on the wetlands for fishing, agriculture, and ecotourism. Pollution, urbanization, and overfishing have all had a negative impact on the lake's water quality and biodiversity. The Suez Canal has led to a decline in the number of migratory birds using the lake as a stopover site (Figure 3 and Figure 4).

Figure 3. Lake Manzala's constructed wetlands and migrating birds with large-scale housing development in the distance. (Photos: anonymized for peer-review).

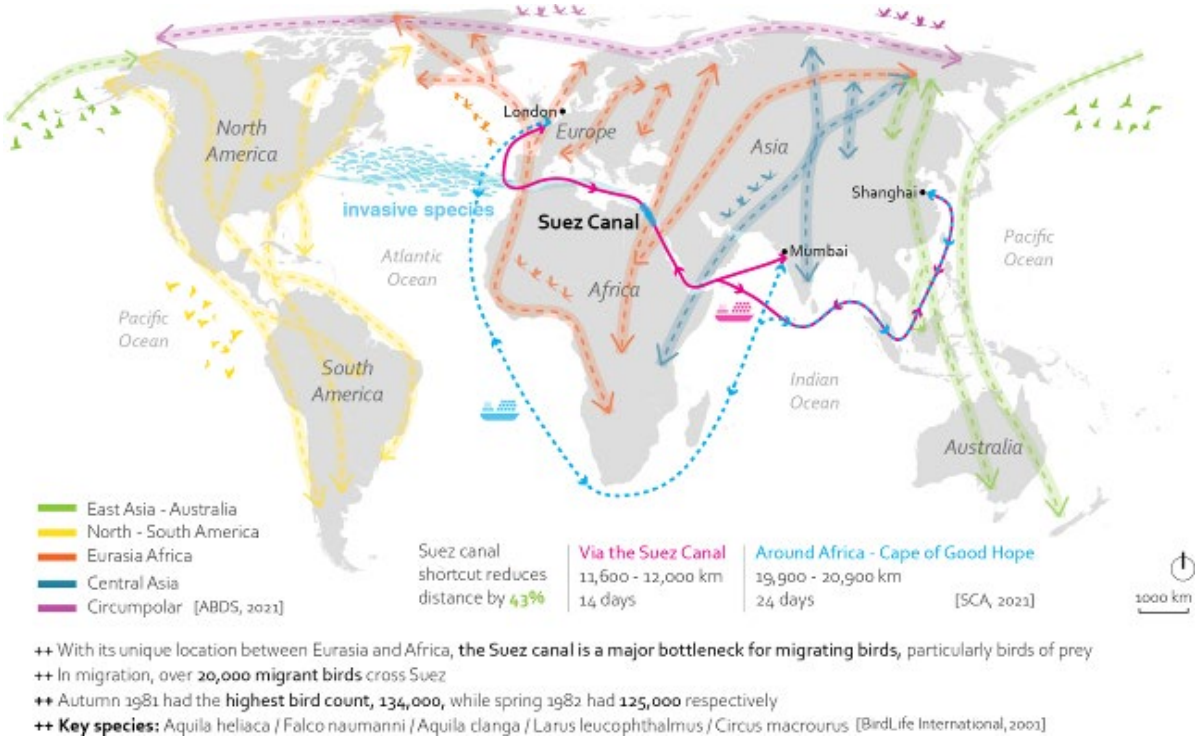

Figure 4. Migrating birds and the Suez Canal. (Graphics: anonymized for peer-review, Lincoln & Michael, 2001).

Further, Lessepsian migration, the movement of marine species through the Suez Canal from the Red Sea beginning in 1869 when the canal was completed led to the introduction of non-indigenous species in the Mediterranean. It includes various fish, crustaceans, molluscs, and seaweeds with varying effects on the Mediterranean ecosystem, including competition with native species for food and habitat, predation on native species, and the spread of disease. With the opening of the New Bypass in 2015, migration of non-indigenous species severely increased, expected to further increase with climate change. There are geopolitical implications of the effects on the fishing and tourism industries, but also on biodiversity conservation demanding continuous monitoring and management (Galil, 2015).

Figure 5. Bitter Lakes Fishermen and Non-Indigenous Species. (Photos: anonymized for peer-review, 2023).

Egypt is prone to be severely affected by climate change in terms of heat waves, sandstorms, and sea level rise see (Barnes, 2022). With the increase in vessel size and loads, the adverse impacts of strong winds such as the sandstorm on the day the Ever Given got wedged in the Suez Canal, are increasing, which some speculate may become more frequent and severe due to climate change see (Masters, 2021). Sea level rise in combination with land subsidence (El Geziry, 2020) is threatening the canal, and its port infrastructure and is likely to affect housing, transportation, and communication networks, industrial sites, and sanitation systems along the Mediterranean Coast, specifically in Port Said (Barnes, 2022) and demand for adaptation.

Infrastructural Networks and Nodes

The Suez Canal today is a ditch canal at sea level and only slightly differing water levels with a maximum tidal range of 65 cm in the north and 1.9 m in the south. The banks of the canal are protected against wave generation by revetments of hard stones and steel sheet piles depending on the quality of the soil further defining the gradient of the cross-section from 4:1 in the north and 3:1 in the south and framed by mooring bollards on both sides of the canal every 125 m in case of emergencies (SCA). For most of its length, the canal is closed off from public access by a protective corridor to each side confined by walls or checkpoints to ensure safety. Constructed in the second half of the 19th century, it has been expanded both with a series of bypasses and in section to accommodate larger vessels and their increasing load. It received a new bypass and expanded in 2015 increasing the potential number of ships and reducing the average waiting time. It involved more than 500 million cubic meters of excavation and dredging works. In comparison, the original canal involved the excavation of 74 million cubic meters (SCA, 2023) (Figure. 6). As the bottom and sides of the waterway are sandy, the movement of ships causes siltation and thus a continuous need for dredging (Hosny, 2021).

The Suez Canal Zone project expands on the existing ports and industrial areas with four new industrial zones in Sokhna, East Port Said, West Qantara, and East Ismailia (SCZone, 2023). The further infrastructure of the canal includes tunnels, bridges, the 320-km Sumed oil pipeline connecting the Gulf of Suez with the Mediterranean as well as several canals: El Salam bringing water and drainage water from the Damietta branch to Northern Sinai and passing underneath the Suez Canal, the aforementioned Ismailia Canal and Bahr El-Baqar Drain with its new agricultural wastewater treatment plant (Presidency EG, 2023).

After overseas labour remittances, tourism, and real estate, the Suez Canal revenues are considered the most important source of national income and hard currency. Toll collection is conducted in the currency unit of Special Drawing Rights, a monetary system consisting of the dollar, euro, yen, and pound sterling (Kenawy, 2016). Approximately 12% of global trade and 30% of global container traffic are moved through the canal with over $1 trillion worth of goods per year. 50 ships pass the canal daily transporting cargo worth $ 3-9 billion, roughly four times more than is moved through the Panama Canal. As a significant route for energy, commodities, consumer goods and componentry from Asia and the Middle East to Europe, the canal's location makes it a key hub moving an estimated 7-10% of the world's oil and 8% of liquefied natural gas. Roughly one million barrels of oil traverse the canal daily. In 2019, 53.5 million tons of ores and metals and 35.4 million tons of coal were transported via the Suez Canal. The Sumed pipeline transports 80% of the oil shipped from the Middle East Gulf to Europe with a capacity of about 2.8 million bpd, yet utilization is often below capacity (MFAT, 2021).

More recently, the Suez Canal Authority (SCA) has proclaimed the transition towards a Green Canal that builds on time and distance saves and therefore less fuel consumption and a decrease in emissions (SCA, 2023). It also includes potential incentives for vessels that use green energy, solar, and wind energy provision for the control stations, and a new partnership with a company for solid and liquid waste collection and recycling from the vessels. According to the SCA, the Suez

Canal has contributed to decreasing CO2 emissions by 31 million tons in 2021 compared to alternative routes, saving fuel by 10.3 million tons, and contributing to saving 53 million tons of CO2 equivalents.

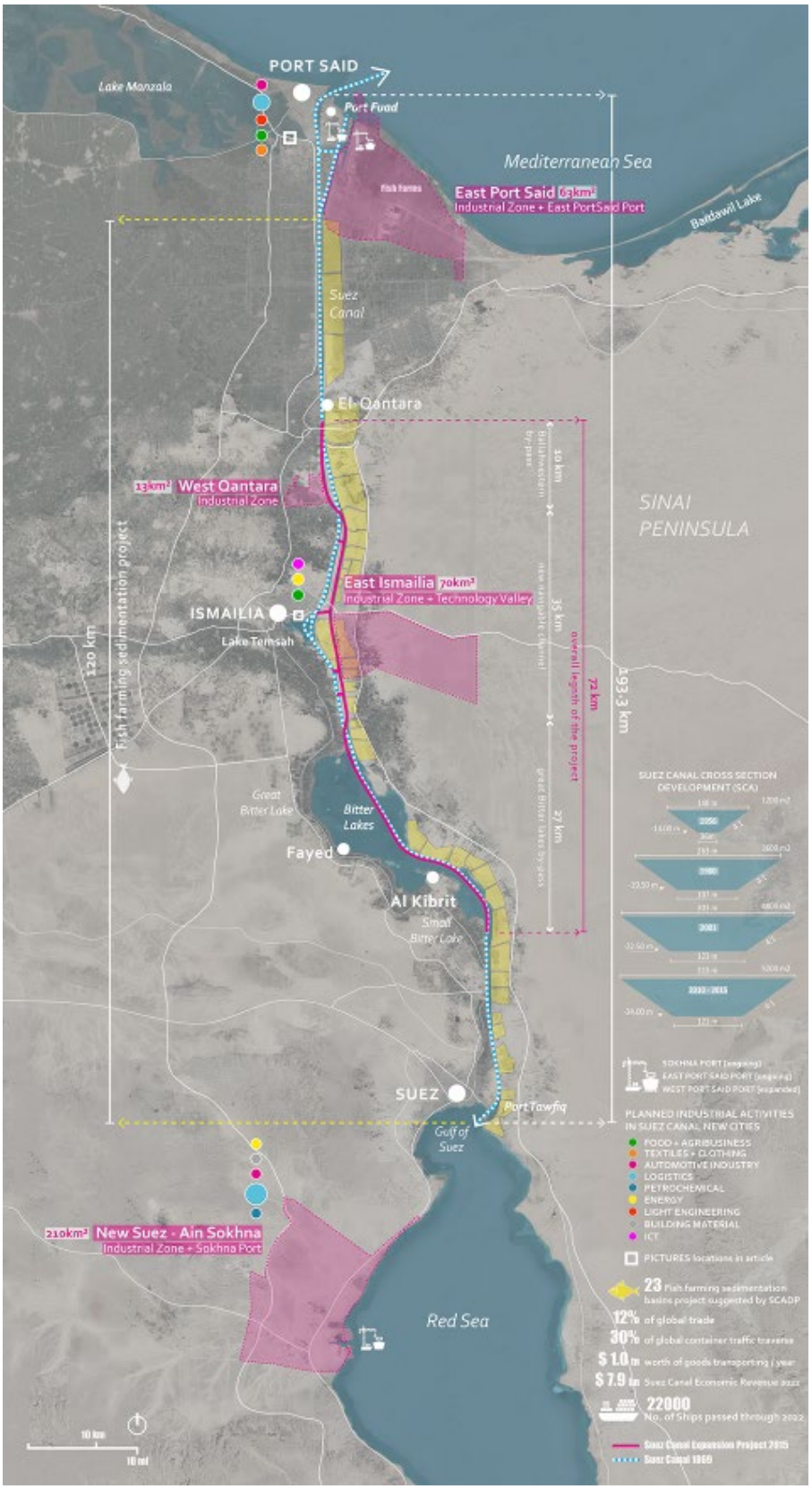

Figure 6. The Suez Canal Development Zone.
(Graphics: anonymized for peer-review, Adopted from El-Bastawisy, 2016; SCA, 2020; SCEZone, 2018).

The planned solar and wind-powered hydrogen production will further shape the dynamic of regional development in yet unforeseen ways (Zgheib, 2022). Egypt's predominantly North-western winds make the western coast of the Red Sea the most wind-intensive area in Egypt hosting large-scale on-shore wind farms in Zafarana, further to the south, already since the 1990s. Only recently a new project was launched by an international consortium to produce 10 GW just South of Suez (Egypt Independent, 2022). The recently agreed-on projects in Neom, Saudi Arabia, and Egypt as part of a global hydrogen transition build on existing transhipment routes to move hydrogen in more transport-friendly forms such as ammoniac. Post-fossil fuel, compressed hydrogen itself is envisioned to be moved through existing oil pipelines. An attempt to import solar energy to Europe from the MENA region a decade ago failed due to the arrogant attitude of the consortium of multinationals. The companies are now back with a plan to use solar and wind energy in the desert as a renewable resource to produce hydrogen (Häusler, 2022) with a plan to start production 2025-26. In return, the energy transition will provide the countries of origin such as Egypt with both solar energy and hydrogen this time. Challenges include high costs and energy inputs, as well as safety risks.

According to the Marsh report (2023), the "just-in-time" nature of shipping produces limited redundancy. To tackle the impacts of climate change demands for physical adaptation of the canal and port infrastructure and finance mechanisms to be combined in a "consistent and structured" resilience strategy. Whereas Chorev (2023) points out that the Egyptian Armed Forces are a major stakeholder in the national economy, the largest investor remains China driven by the canal's geostrategic importance also as a part of the Belt and Road Initiative. The canal is a highly significant naval trajectory for the US, China, Israel, Iran, Russia, and the European navies. The Suez Canal as a source of economic revenue is potentially threatened by alternative routes through the Barent Sea while some see the Canal standing at risk of being contested by other nation-states and multinationals thus potentially undermining Egypt's sovereignty (Chorev, 2023). Throughout its history, the canal was closed six times: the shortest period being three days in 2021 when the MC Ever blocked the canal with a severe impact on global supply chains. The longest closure being eight years following the Egyptian-Israeli 1967 war (SCA, 2023), a testimony of the canal's challenging geopolitical location that we are currently witnessing once more.

Urban and Industrial Development

The Suez Canal has brought forth multiple generations of cities originally aligning the western shore and since then expanding to the Asian side of the canal: Suez, Ismailia, and Port Said in the 19th century, Port Fouad in the 20th and New Suez, East Port Said, New Ismailia, and New Qantara in the 21st century. As much as the canal is a driver for development, according to the Environmental Justice Atlas a.o. the new bypass has led to the eviction of villages east of the canal that had evolved after the end of the Israeli war in 1967 (EJAtlas, 2019).

In the 19th century, Port Said itself was only a small fishing village with a population of just a few thousand that quickly grew on land reclaimed with soil excavated from the Isthmus of Suez (Huber, 2017). With the opening of the Canal in 1869 it grew into a major port and commercial centre, with a population of over 600,000 by the early 20th century. Today, it is home to a diverse population and industries ranging from shipping and logistics to manufacturing and tourism, its port handling manufactured goods, agricultural products, and raw materials. Ismailia was founded in 1863 as a base for the construction of the Suez Canal and has since grown into a major city. The nineteenth-century cities were defined by European Afrang and Arab quarters with different levels of landscape development and infrastructure provision (Gamal-Eldin, 2020). The destruction of entire neighbourhoods during the Egyptian-Israeli War (June 1967) has led to a change in urban fabric with more homogeneous developments to follow (Hussein, 2018).

Hussein (and others) criticize a general loss of continuity and homogeneity of urban character in many residential districts, lacking privacy and the absence of local identity and character in areas of urban expansion, random demolition of valuable buildings in historic areas, encroachment on green spaces and vacant land and a general lack of awareness and preservation of historically distinct buildings and areas.

The city of Suez also experienced significant urban development. As an ancient trading site and Greek town, it grew in relevance with the canal construction works in the 1860s. Today, Suez is a major industrial centre, home to oil refineries and natural gas processing facilities that supply fuel around the world. Its port handles a significant amount of oil and gas tanker traffic. The ports of Ain Sokhna and Port Tawfiq are located on the Red Sea handling manufactured goods, agricultural products, and raw materials.

The canal's importance as a shipping route has also led to the development of several agricultural projects along its banks including plans to reclaim desert land for cultivation with approximately 16 million hectares, large-scale greenhouse projects in Ismailia provided with water from the Ismailia Canal to produce for export (Presidency EG, 2023) and fish farming along the Eastern shore of the new bypass with 23 sediment basins over a length of 120 km (Kenawy, 2016) (Figure 6). Today 1.8% of the country's rice and 1% of its wheat are produced along the canal.

The Egyptian population's commencing increased growth and resulting rural migration in the 1950s led to both planned and unplanned growth around existing urban areas. Unplanned growth mainly on agricultural land (Radwan, Blackburn, Whyatt, & Atkinson, 2019) further pressured food security evoking counter strategies to contain urbanization. Egypt witnessed several 'generations' (Hegazy & Moustafa, 2013) of New Desert Cities each characterized by the urgencies and political agenda of their particular time. The first and second generations of New Cities did focus on providing social housing for middle- and low-income groups. This changed in the early 1990s when the third generation increasingly gave way to a highly commodified real estate market.

21 new cities have been planned in the desert by the governmental New Urban Communities Association (NUCA) including the construction of the New Administrative Capital and New Alamein aiming to relocate 28 million people in total. Yet, target populations are far from met. According to a recent study by TADAMUN, not a single new urban community has reached NUCA's population targets (only 3-27%) (Tadamun, 2015). Instead, these new cities have "leveraged abundant resources around temporary employment, short-term profits, and long-term political legacy establishment" while finished housing units remain unoccupied. In 2017, the Central Agency for Public Mobilization and Statistics of Egypt (CAPMAS) revealed that 12.8 million housing units were vacant.

As of today, NUCs fail the needs of lower-income groups. Structural reasons like lacking density and public transport, unfit financing models, ineffective distribution practices, the affordability gap, unsuitable floor plans, as well as the remote locations of social housing areas are causes for the current housing crisis (Sims, 2010; Abouelmagd & Abouelmagd, 2014; Shawkat, 2015). As a result, large parts of low-income groups remain in informal or older urban areas. The question is if the New Suez Canal Project with its new industries will be able to change the disconnect between livelihoods and national housing schemes. It remains to be seen, how new jobs projected to be created match the current workforce of the informal sector and the 600,000 entering the employment market annually remains to be seen.

With the construction of the canal also came its colonization. In 2018, the three Canal governorates constituted 2.7-2.8% of Egypt's population similar to 2006, indicating no increase in population growth in the area in the past two decades. With accelerated industrial development, the population in the Canal region is again expected to grow: East Port Said with 250,000

inhabitants, New Ismailia with 57,000 housing units assuming five-person households together with West Qantara accommodating 350,000 residents and the recently started first phase of Ain Sokhna's expansion of New Suez with 2,000 housing units of 90 square meters each and social infrastructure on an area of 300 feddans (1.26 km2) but is expected to reach a target population of 60,000 inhabitants on an area of 2000 feddan (8.4 km2) upon completion. The planned SCZone development would total a population increase of 350,000 and potential job creation for 270,000 (SCZone, and Egypt Today, 2022) if, and that would be a first, population targets and development goals are met.

Research Recommendations

In summary, the layer analysis shows inherent challenges and risks of Suez Canal Zone Development. The anthropogenically transformed landscapes of the Suez Canal region severely impact flora, fauna and habitat, agricultural production and urban foundations. Infrastructures rely on continuous adaptation and maintenance adding to the need for perpetual economic growth. Given the national urban development agenda and its current failure to provide for large parts of the population, one may assume that the new urban foundations along the Suez Canal may do better in terms of linking urban growth to industrial production sites. It remains to be seen if this is a match for potential workers to incentivize them to move to the Suez Canal Zone. All layers are severely impacted by geopolitical development, global economics and climate change. To enable an increase of resilience for the Suez Canal Development both its existing and new cities play a central role. How decentralized, small-scale, nature-based, and passive measures may be integrated into the current planning process demands paradigm and policy change as well as learning models. Making diversification part of the ongoing large-scale, top-down, and path-dependent development of the Suez Canal Region therefore demands further research (1) by design: to apply these to the specific context and adapt existing plans (2) to show the inherent social, economic, and environmental benefits to national and local decision-makers and stakeholders (3) to create new economic models that integrate long-term benefits beyond the initial investment and (4) to define national and possibly international policies that support a shift in planning and execution. Building on a transformative science approach to create alternative models to the path dependencies of a growth-reliant economy, universities could play a propositional role in support of a more integrated development and according strategies to implement a complementary urban agenda as an alternative to previously informal urban responses.

Conclusion

All the World's Problems Can Be Solved in a Garden…(G. Lawton)

Infrastructure relies on maintenance and adaptation and adds to the need for perpetual economic growth. The world's current response to large-scale industrial development, the global so-called "green transition" that the Suez Canal is a part of and that reflects in processes of continuous large-scale landscape transformations paired with accelerated urban and industrial growth must be one where cities are able to increase their level of autarky to accommodate inherent socio-ecological challenges. A legacy of colonial, extractive practices and a global economic system that fails to provide spatial justice exacerbated by recent developments (climate change, wars, pandemics, and others), show the fragility and lack of resilience of our built environments globally. This offers an enormous capacity for urban planning and architecture to move beyond the provision of sectoral functions (housing, work, leisure, and transport) to become more self-providing through nature-based solutions. This trans-industrial path demands a paradigm change towards climate and culture-specific, economically viable models that cater to the given socio-ecological context: In case of success of anticipated models of industrial growth they will be able

to increase the level of various ecosystemic services and thus positively impact the ecological footprint while in a worst-case scenario where industrial developments fail due to given risks, they may serve as a likely needed alternative to provide food, water and energy.

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