New Sahelian Cities for Desert Reversal and Climate Action

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Abstract
Expanding deserts since the Ice Age, and climate change starting from the fossil fuels' combustion of the Industrial Revolution are twin spirals tipping the globe over the ecological knife edge. Most deserts have resulted from overgrazed pasturelands, which came from destruction of rainforests, the former repositories of freshwater.

The Great Green Wall project, an African Union-led initiative to reverse desertification in the Sahel-Sahara from 2007 onwards, can integrate new livable cities, with dwellers strengthening fragile ecosystems, increasing sustainability and resilience, and combatting climate change in the Sahel. Providing infrastructure - clean energy, reticulating borehole water for agricultural and human consumption, and sanitation - are achievable for one of Africa's eight regional development blocs, the Community of Sahel-Saharan States (CEN-SAD) that almost overlaps three more, with financiers' support such as Investor Network on Climate Risk.

These strategies should follow scalable project models for measurement, assessment, and records in continuous research. New Sahelian cities incorporating agro-industrial opportunities for ranching, milking and meat processing will most likely stem security crises from nomadic herdsmen free-ranging livestock, contesting farmlands in the Gulf of Guinea. This solution proactively engages architecture on issues of agriculture and settlements, livelihood, terror, and security under the UIA2020 Congress theme - all the worlds: just one world. Architecture 21.
The Arab Maghreb Union is worth studying on their life expectancy, climatic adaptation for social harmony, while adapting Israel's environmental management. Rio2020 promises a greater leap since Rio1992, proffering solutions to global challenges.

Origins of Sahara Desert

According to German scientists in the American Geophysical Union, 1991: "changes in the earth's orbital tilt about 3,500 BC appeared to trigger the desertification of the Sahara. Thus, civilization grew away from the arid zones to the Euphrates, Nile, Niger and other river courses[1]."

As the Sahara[2] grew warmer and drier, the next processes were the expansion of the desert and its fringes, called Sahel in Arabic. The Maghreb nations crowded the temperate Mediterranean coasts as humid forests receded unabatedly to the Gulf of Guinea, while the Tuaregs, Berbers and others (including the Matmata of Tunisia) have adapted to desert living with some mitigation, much resilience and lesser sustainability: these would be explored herein. The aggravating challenges of the Sahel-Sahara range from biophysically degraded land, water

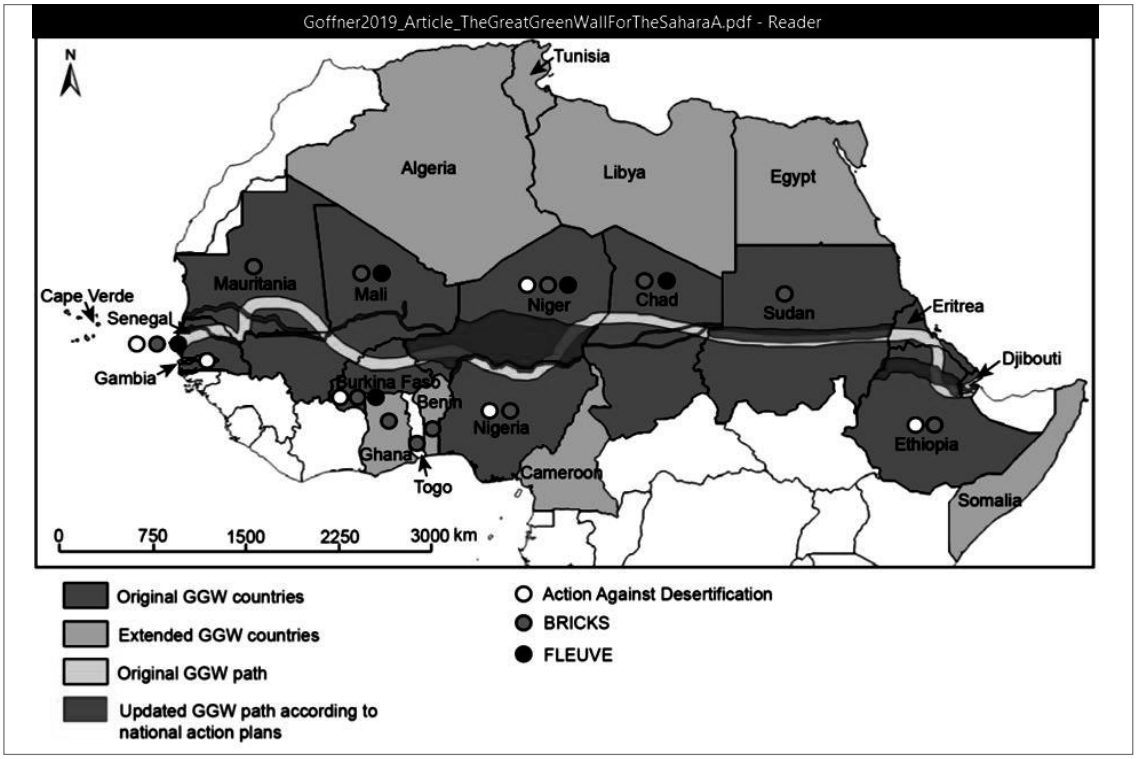

Figure 1. Map of Great Green Wall across the Sahel-Sahara region - from Deborah Goffner et al. (2019).

scarcity, desertification increased by open grazing, insecurity hotspots from herder-farmer conflicts, low human development indices, all contributing to multidimensional poverty trap situation calling for wholesome solutions.
Land degradation has resulted in various desert landforms - sand dunes (erg), gravel plains (reg), dry valleys (wadi) and stone plateau (hamada) which needed recovery for best uses.

Origins of Climate Change

Climate change is the cumulative effects of exploitation and burning of fossil fuels - coal, oil and gas - to power factories, railways, internal combustion engines and power generators from the Industrial Revolution (circa 1780). Waste compounds and greenhouse gases discharged onto the land, sea and air have distorted the natural cycles of water, air temperatures and pressures, and contents of the atmosphere and sea. Global efforts for solutions to climate change and desertification among the nations have separately produced such results as: the Intergovernmental Panel on Climate Change, the United Nations Framework Convention for Climate Change (UNFCCC), United Nations Convention to Combat Desertification (UNCCD) October 1994 onwards, UN Convention on Biodiversity (UNCBD), etc.

The earliest attempts at resolving these environmental challenges are traceable for climate change, to Rachel Carson's book, Silent Spring[3] (1962), which spurred US Senator Gaylord Nelson and Green activists to the first Earth Day[4] 22nd April, 1970 and onto the UN Earth Summit Rio 1992. Likewise, the Great Green Wall Sahara-Sahel Initiative[5] (GGWSSI) (Fig. 1) started by the Community of Sahel-Saharan States (CEN-SAD) and adopted in 2007 by the African Union, was mooted by Richard St. Barbe Baker[6] in 1954, incubating over fifty years.

The GGW[7] project covers 100 million hectares of fifty-kilometre stretch of trees to halt the desert from Guinea to Somalia across the Sahel, to recover degraded land, for food security and to absorb carbon dioxide for climate action. This ambitious effort embraces twenty-one North, West and East African nations[8] - Burkina Faso, Cameroon, Chad, Djibouti, Eritrea, Ghana, Mali, Mauritania Niger, Nigeria, Senegal, Sudan, Algeria, Benin, Cape Verde, Egypt, The Gambia, Libya, Somalia, Tunisia, from 1998 to 2009.
Beside these national governments, other stakeholders in the multi-billion dollar initiative

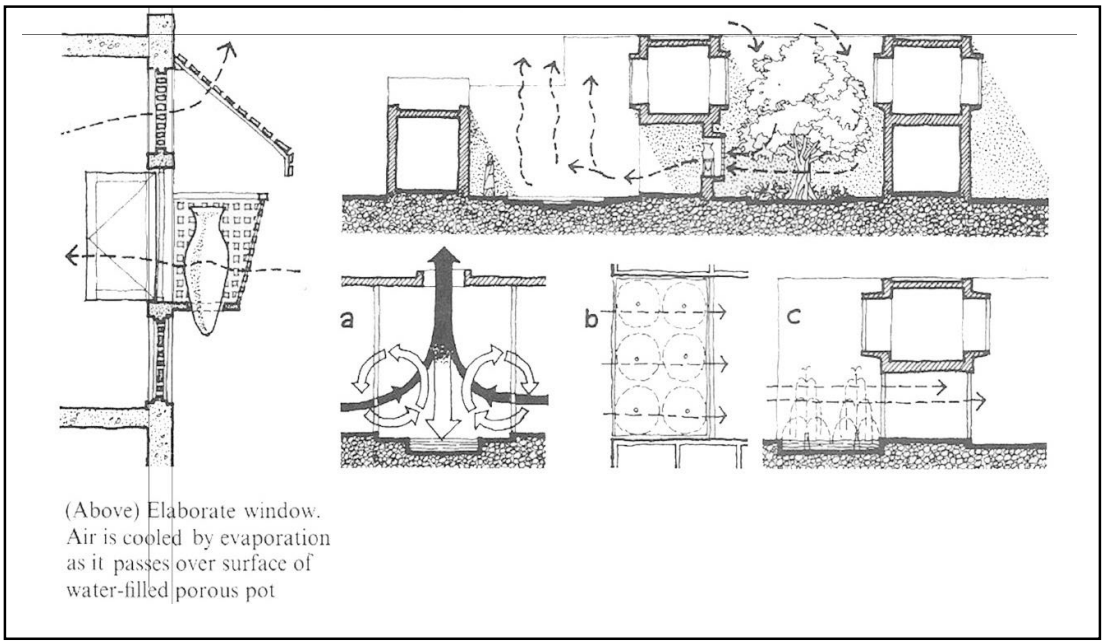

Figure 2. Evaporative coolers in front of window hoods in arid climate and wind convection over interior water pools. Source: Konya, A. Design Primer for Hot Climates, London: The Architectural Press Ltd. 1984.

are international organizations, the business sector and civil society.

The Crowther Laboratories of ETH, Zurich, Switzerland has published in *Science* journal estimates of 900 million hectares of global land was required for reforestation to absorb 205 billion tonnes (about two-thirds) of man-made carbon emissions from the Industrial Revolution (circa 1780) to date.

Solutions Proffered

Forests are the fastest, safest and most effective means of climate action: inhaling carbon dioxide and exhaling oxygen, they are earth's lungs, man's pharmacy and food pantry. Woody vegetation has contributed to building resilience in the Niger Republic through farmer-led natural regeneration of trees in the Maradi and Zinder regions, thereby halting a national socio-economic downward spiral[9].

Where the Green Dam in Algeria, a forerunner of GGWSSI, failed in its 1970s objectives to halt the Sahara desert as a monoculture afforestation, Pieter Hoff's *Groasis Waterboxx* now succeeds with trees, fruits and vegetables. Dr. Wangari Maathai[10] pioneered Kenya's Green Belt Movement in 1977, planted 30 million trees and received a 2004 Nobel Peace Prize for environmental activism.

Planting trees has become money spinners for enterprising global companies using scalable business models, restoring degraded agricultural lands and forests for benefits to the planet and business. Tree-based restoration brings many benefits: improving biodiversity, air and water quality, soil health and providing food and forest products, sustainable timber, mitigating climate change and deserts, creating rural jobs and recreational opportunities.

The World Resources Institute[11] collated over 140 companies involved in global reforestation efforts, and listed fourteen under four themes for a report: **Technology** (Dendra Systems, Land Life Company, TerViva, F3 Life), **Consumer products** (Guayaki, Tentree, Ecosia), **Project Management** (Brinkman and Associates, Fresh Coast Capital) and **Commercial Forestry** (New Forests, The Lyme Timber Company, Komaza, EcoPlanet Bamboo and Symbiosis Investmentos). The business model advantages, terms and conditions of the companies determined the collaboration needed for each terrain. Dendra Systems engaging two workmen operating ten drones daily planted 400,000 pre-germinated pods of saplings or 100 million per year. Similarly, Ecosia GmbH based in Berlin, Germany has planted over 6 million trees mostly in Burkina Faso among others, while promoting

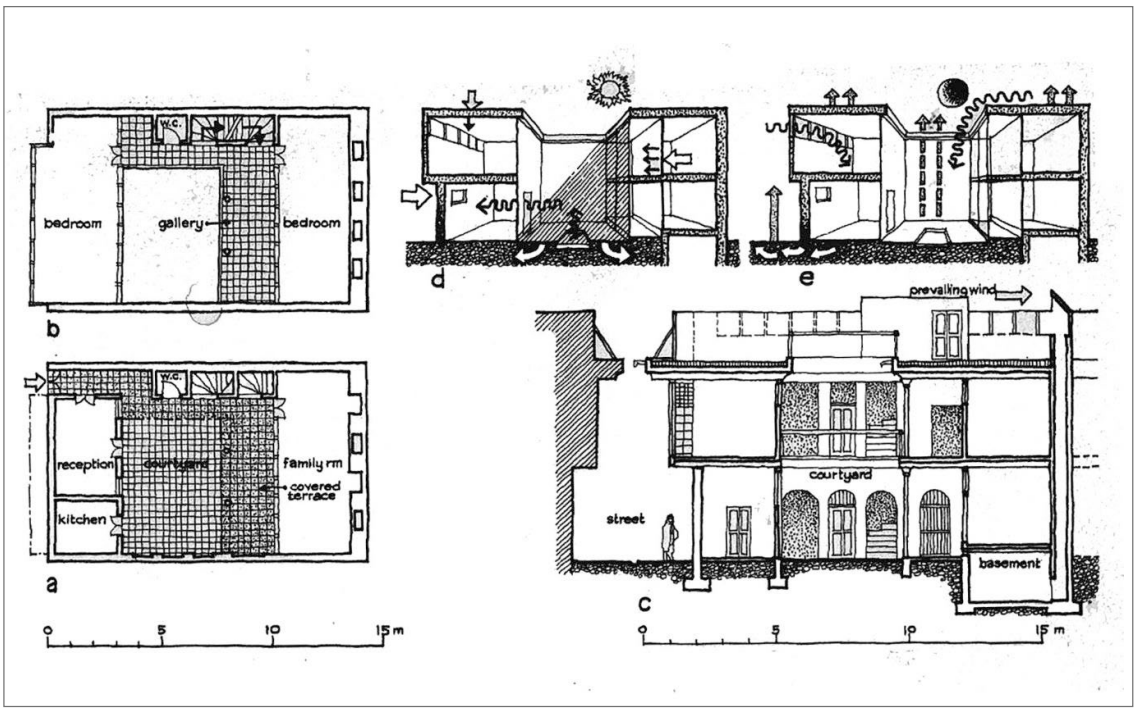

Figure 3. Enclosed Courtyards and Wind Towers as means of cooling the house interiors in arid regions. Source: Konya, A (1984) Design Primer for Hot Climates. London, The Architectural Press Ltd.

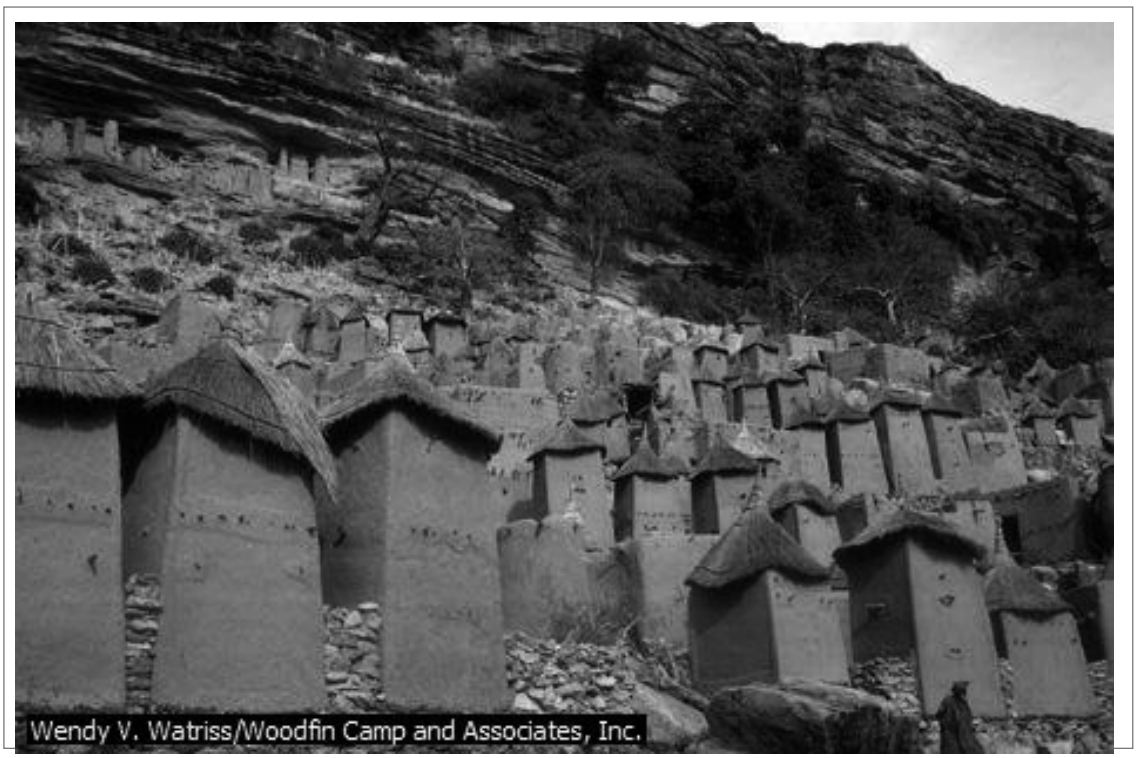

Figure 4. Millet granaries in a Mali village showing architecture and construction technology for food preservation, climatology, mass production and security - heritage of an ancient empire. Source: (Microsoft Corporation, 2009).

native, mixed-species forests to enhance biodiversity restoration.
Thus, 100 million hectares of GGWSSI would require 280 workers operating 1,400 drones for 140 billion trees over 10 years, and another 560 workers for logistics on Dendra Systems,.
The huge budget required for this **'new restoration economy'**[12] provides opportunities for young entrepreneurs raising saplings and planting forests to absorb 22.5 billion tonnes of atmospheric carbon. Planting new forests and restoring old forests allows regeneration and serial cropping within the project sponsors' 2030 completion date.

Forests and Water Courses

For strategic purposes, the GGWSSI project calls for embracing the region's water courses - the Senegal, the Niger, Kebbi and Yobe in Nigeria, the Chari-Logone in The Chad, the Nile and its tributaries in Sudan and South Sudan, and Juba and Shibeli in Ethiopia and Somalia - for the forests to expand in coverage and sustenance. This approach would encourage reforestation to support and nourish ecosystems from the coastal rain forest belt up to the Sahel, the most critical for strong representation. Curing the southern belt on naturally grown forests would revive freshwater repositories in the semi-arid Guinea Savanna north and reverse desertification.

Replenishing Lake Chad[13], a strategic water body straddling four Sahelian territories (Figure 5) would trigger cross-cutting solutions. Italian firm Bonifica Spa proposed the 50-billion USD Transaqua Project[14] in 1985 to divert and channel River Ubangi over 2,400 kilometres from the Congo Basin into River Chari to recharge Lake Chad. However, pumping River Benue's wasting floods through a 500-kilometre canal within Nigeria into a dredged and de-silted Lake Chad would, at lower costs, recover the ecosystems for fishing, irrigation farming and livestock rearing, restore aggravated livelihoods for over thirty million population living on the lake, and reduce regional security challenges. The proposed canal's catchment basin would afford planning opportunities for reforestation, new climate-smart cities and eco-tourism on the waterway connecting commercial and industrial activities to sea-bound bulk cargo shipping, with railroads linking the outlying Sahelian regions.
Most rain-forests flourish during the wet season as increasing farmlands and uncontrolled urbanization have consumed natural vegetation, fostering gully and sheet erosion and also releasing insects and pests from their natural habitat to invade mankind with new diseases[1].

Precipitation would transform formerly extinguished vegetation cyclically to blossom with stable biomes and microclimates, and reduce global warming significantly. Despite arid location and meagre rainfall, Israel has developed quality water management, exporting water security to many nations while banking on heritage seeds for food security.

Tree species and Soils

Millettia pinnata[15] is a multi-purpose leguminous oilseed tree gaining attention for its versatility, producing food, livestock feed and biofuels, and promising to fill global annual demand above $500 billion. However, it would not become 'another oil palm plantation' on forest destruction and biodiversity loss ticket: it rehabilitates soils in highly degraded areas, fixing nitrogen and reducing fertilizer needs. Land Life Company patented Cocoon, a product to grow trees in dry and degraded land or arid landscape, improving on ancient Mesopotamian farming technique where farmers buried water-filled clay pots around newly planted trees.
Desert soils could use the 'soilization'[16] technique developed and patented by Chinese Professor Yi Zhijian for recovering and improving degraded land. Similarly, Sahel-Sahara can adapt Israel's land management practices in the Negev desert, study soil and rock samples for their contents, grind rocks into fine powder, and in most cases without fertilizers. Then, networks of irrigation drip pipes buried beneath trees or crops at certain flow rates minimizes transevaporation while turning deserts into blooming forests.

New Sahelian Cities and Finance

Potential mining and quarrying sites would require geological mapping, and recovered land would go for agriculture and settlements. On average, Sahel region can allocate 40 percent of land for agroforestry, 30 percent for arable land, 20 percent for habitation, and 10 percent for ancillary uses.
New livable settlements in arid zones are novel challenges beyond the eleven whole rock-hewn Church buildings in Lalibela[17], a twelfth-century Ethiopian king's capital, or the over 2,000-year-old subterranean architecture of Matmata[18]. These desert dwellers resisted all attempts to move them from their troglodytes

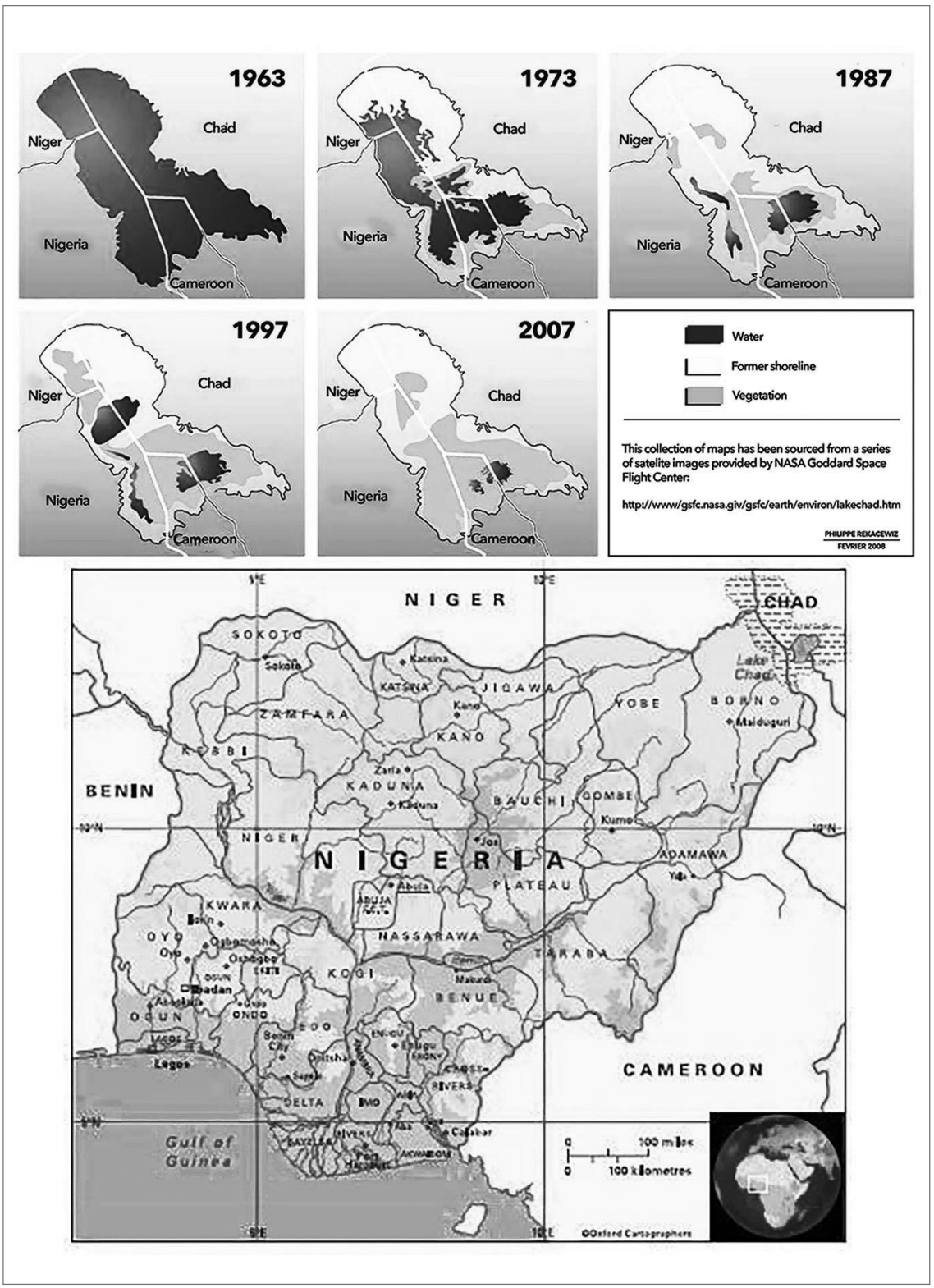

Figure 5. Map of Nigeria; and satellite images of Lake Chad's diminishing extents in four Sahelian countries on timelines from 25,000 square kilometres (1963) to about 2,000 square kilometres (2007). Sources: Goddard Space Flight Center http://www.gsfc/nasa.gov/gsfc/earth/environ/lakechad/chad.htm through www.environewsnigeria.com and www.cedol.org

after a 1969 flood crisis brought them to public attention.

New Sahelian cities integrating infrastructure are projected to reduce herders' migration when they adopt agro-industrial opportunities of ranching in tsetse fly-free regions, with forest restoration on formerly degraded land. The clarion call is to move towards Zero Carbon cities by 2050 as in Tokyo Zero Emission Strategy[20] working with Ceres Investor Network on Climate[21] (INC) – a 170-strong institutional investors' network posting over $26 trillion assets under Bloomberg New Energy Finance: Mapping the Gap[22] for the Paris Climate Agreement (2015-2040).
The strategy envisions aggregated solutions through decarbonization in all sectors - energy, buildings, transport, and industrial - to limit temperature rise below 1.5^{O}C for a future of Sustainability and Resilience, while minimizing wastes in food, plastics, CFCs and other resources on 3Rs (Reuse, Reduce and Recycle). Likewise, mitigation of climate change impacts, risks and disasters, and adaptation strategies for heatwaves are to couple on climate action for carbon reduction and preparing for changing climate with targets and actions towards 2030, and finally 2050.

Sustainable Development Goals would be achieved: wealth, food, health, education, clean energy, clean water, sanitation, livable cities, employment, economic growth, climate action, community peace and harmony with inputs from many professions in the environmental and social sciences, arts and humanities, science and technology for holistic model solutions adaptable to other climes. The Sahel's population is expected to double by 2039, adding 250 million more people to the project's urgency.
Sahara desert currently swallows up about 35,000 hectares annually, drying rivers and water bodies in the Sahel: herder-farmer aggression here stretches southwards for herders searching for water and grazing land.
Sahel-Sahara offers opportunities for climate-smart solutions, notwithstanding huge climate impacts on passive contribution: studying Maghreb successful adaptation to desert diet and lifestyle on modest per capita GDP[23] yields surprising patterns of longevity in Libya, Tunisia, Algeria, Egypt and Morocco to instruct all the worlds.

Most futurists have explored studies of transportation, energy, water and food systems, waste evacuation, recycling and disposal according to subjective perceptions: however, mankind has come to a place of narrow choices in an emergency. This project must be powered on backbones of transport and communications systems, and renewable energy without carbon footprints in planning, construction, operations and maintenance, or deconstruction.

Old Climatological Principles

New Construction Technology

From the foregoing, the climatological principles that have served Africa's arid climes over two centuries deserve further exploration like China building whole towns and villages – dwellings, factories, schools, hotels and offices – entirely underground in its northern loess (silt) bed over the past 80 years, like in the Arizona desert, and in South Australia for miners, whose houses were carved into the soft clay stone of the area[24].
New problems created by modern materials displacing the old thick-wall construction in arid regions need mitigation through high performance insulation. Extensive fenestration facing the Sun's daily path would not serve the hot days and wintry nights. These feedback must be factored with framed structure construction to go with multi-storey dwellings and efficient thermal performance round the seasons.

Conclusions

This paper's deliverables are sustainability, feasibility and socio-physical impacts of recovered land for desert reversal, and new forests for climate action, new cities on a new canal, energy, finance, social harmony, better security prospects and life expectancy. Can Benue River floods recharge Lake Chad within 10 years? Would the lake and canal be sustainable afterwards without draining the existing water-courses? Can the new vegetation spur more natural rainfall for desert reversal and climate action? Such development engenders a quantum leap.

Endnotes

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