Dear Readers,

Throughout the past years, I have privately worked on an interdisciplinary approach which I had in the back of my mind since 2009. It deals with the idea to mitigate several of today's most urgent problems but with a strong focus on mitigating climate change. Thus, the attached article 'Green Deserts – A Wholistic Approach to Solve Today's Major Problems' might be of interest for anyone dealing with sustainability & environmental science or energy & fuels.

The article is kept to a limited number of words (i.e. less than 2,500), corresponding to limits set by most publishers. In my humble opinion, publishing this article shall (re-)animate the current debates in international, national, and also local politics. For example, there are currently some tendencies in Germany whether to restrict the inflow of foreign people. Since the resources of any country are limited, such discussions arise the sooner or later. Thus, one solution to such financial but also social problems is to e.g. provide potential emigrants from foreign countries the opportunity to stay in their own country and have a life worth living there.

For instance, in all former colonies in Africa there would be a very good chance for all kinds of supporting actions (also as some sort of reparations) by providing the infrastructural base to the local societies to build a strong and mostly independent on their own. Especially, North Africa is constantly facing natural and social hazards like long-term droughts, hunger crises, poverty and, hence, also criminal gang activities or civil wars. Of course, there is no guarantee setting up a working infrastructural base will lead to peace and prosperity. But if there is any potential, wasting it – or even worse – simply watching it passing by is a crime against humanity in the first place.

On the brink of switching from fossil fuels to electricity for driving almost all kinds of vehicles, motors, and mobiles, there is great chance to establish long-term cooperation between 'The Global North' and 'The Global South' at eye level. One of Africa's biggest potentials is its exposition to sun radiation and the opportunity to produce large amounts of free, clean, and hence sustainable energy. If the rich North provides the infrastructure, the poor South can produce that energy in return. Along with this measure, there arises the need to set up the educational infrastructure for providing the relevant working skills.

For this, the integration and also the extension of existent humanitarian aid missions or programmes can be a prominent part since some of them already provide basic infrastructures for feeding, caring, nursing, schooling, and technical support in these poor regions. By this, we can establish a humanitarian net which might be able to support the locals in staying in their home area as long as possible. Nobody wants to give up home unless one is forced to.

But energy, education, and work are only one part of the solution.

Dr Guido Bohmann
Environmental Scientist | Remote Sensing Analyst | GIS Analyst | Software Engineer | Research Coordinator

PO Box 1229, D-49361 Vechta, Germany

https://green-deserts.net
https://green-deserts.org

The Green Desert concept also wants to provide enough food and freshwater to the local population. Accordingly, the fruitless deserts sands have to be replaced by fertile farmable soils. We suggest the usage of planetary mills which can not only replace but also convert these desert sands into artificial silty fractions.

Hence, we propose a terraforming which not theoretically takes place on far-away spheres in space but literally on our home planet. Consequently, we also think that our concept might be of interest for space agencies which aim to transform some extra-terrestrial bodies in future times.

We also propose an anticipation of the rising of sea levels from melting polar ice. In our opinion, we do not need to build higher dykes nor pay high compensation amounts for flooding hazards because we could lower the sea levels in advance and use the water as freshwater or for irrigation. Alongside, we could use this opportunity to filter out any microplastics poisoning almost every creature in marine food chain and, at its end, ourselves.

Accordingly, we would be very grateful if you would find this article worth sharing or publishing in any magazine or online resource.

Yours sincerely

Guido

Dr Guido Bohmann

Environmental Scientist | Remote Sensing Analyst | GIS Analyst | Software Engineer | Research Coordinator

PO Box 1229, D-49361 Vechta, Germany

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Green Deserts – A Wholistic Approach to Solve Today's Major Problems

Summary

Usually, desert sands do not have the potential to store nutrients and moisture to nurture crop plants. But converting coarse grains into finer materials like silt and loam will provide a chance to terraform an almost sterile soli into an artificial fertile fabric, especially in regions where hunger and starvation is on the daily agenda, and moreover, almost always on top of it. Currently, desert regions are only used for deriving solar energy or natural resources like sand, or oil, gas and water lying deep beneath the topmost soil layers. Here we show how a sustainable terrestrial terraforming can be realised in desert regions while also having a wholistic effect on even far away regions. Contrary to expectation, we propose the construction of plants of solar greenhouses in some of the hottest areas in the world. Whereas greenhouses are widely used in temperate zones to grow tropical or subtropical fruits, they seem to never be required or simply unnecessary in such latter zones. Our concept will show that greenhouses are also useful in hot and inhospitable environments since they provide closed systems which can easily be controlled. In addition, we also propose a partial, whether initial or subsequential use by humans. Thus, a plant of solar greenhouses not only will produce food and energy. It will also provide working and living spaces in regions where decent work is nowadays hard to find. By this, local problems like emigration or civil wars hopefully can be minimised, too.

Basic Concept

Chernozem is well-known to be one of the most fertile soils in the world. Firstly, this is because Chernozem can be found in temperate zones with a sufficient amount of rainfall or adjacent rivers to constantly provide water. Secondly, it is because the soil structure is optimal for growing plants: it has a base layer out of clay or loam that works as an almost impermeable barrier to keep nutrients from being washed out. On top of that barrier is a silt layer which offers lots of small pores to keep nutrients, air, and water available to the plant's roots. On top of this nutrient storage there is a sandy layer that can be easily penetrated by the plant's roots but also by soil animals. Accordingly, nutrients and organic matter can get transported from the surface down the very basic layers very easily, too. Thus, Chernozem is a perfect storage of nutrients and organic matter which can be exploited by the crops planted on top of it.

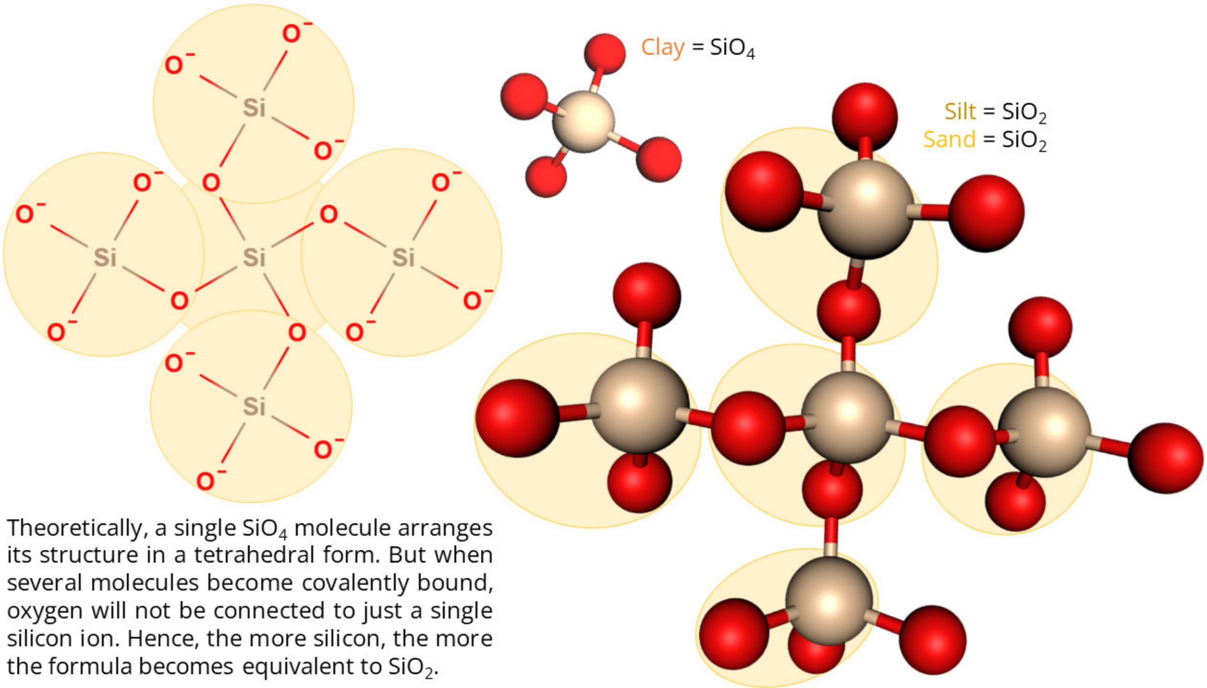
Deserts sands can be considered to be completely the opposite: they only consist of coarse or medium sands which are way less dense and hence much more permeable. Thus, water can simply pass through these layers while washing out any nutrients coming across its path.

Accordingly, the Green Deserts concept consists of the following steps:

1. Converting deserts sands into artificial layers of fertile silt and water-stopping clay.
2. Encapsulating these artificial soils into a standardisable environment (SE) regarding
    a. irrigation & water consumption
    b. cooling & air conditioning
    c. fertilisation & nutrient supply
    d. bioturbation & pest control
3. Supplying that SE with the necessary
    a. freshwater
    b. energy

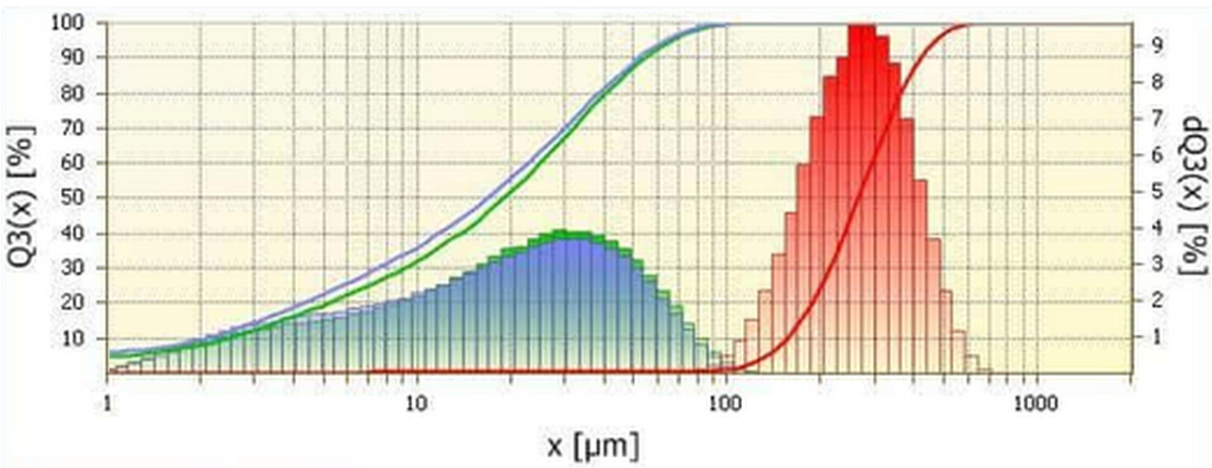
4. Creating the working environments for the personnel running and controlling the SE

Planetary mills are able to break sand grains (size: 2 mm – 63 µm) into silt (63 µm – 2 µm), or clay particles (2 µm – 63 nm) in a reasonable time frame.



Theoretically, a single SiO_4 molecule arranges its structure in a tetrahedral form. But when several molecules become covalently bound, oxygen will not be connected to just a single silicon ion. Hence, the more silicon, the more the formula becomes equivalent to SiO_2.

The following diagram shows cumulative grain size distributions before and after grinding processes with two different types of mills and running times[1]. The red curve shows the distribution of the input material, consisting of medium sand (630 µm – 200 µm) and fine sand (200 µm – 63 µm). The green curve represents the distribution of that sand having been grinded 5 minutes in a planetary ball mill whereas the blue curve shows the result of 30 minutes in a mortar grinder:

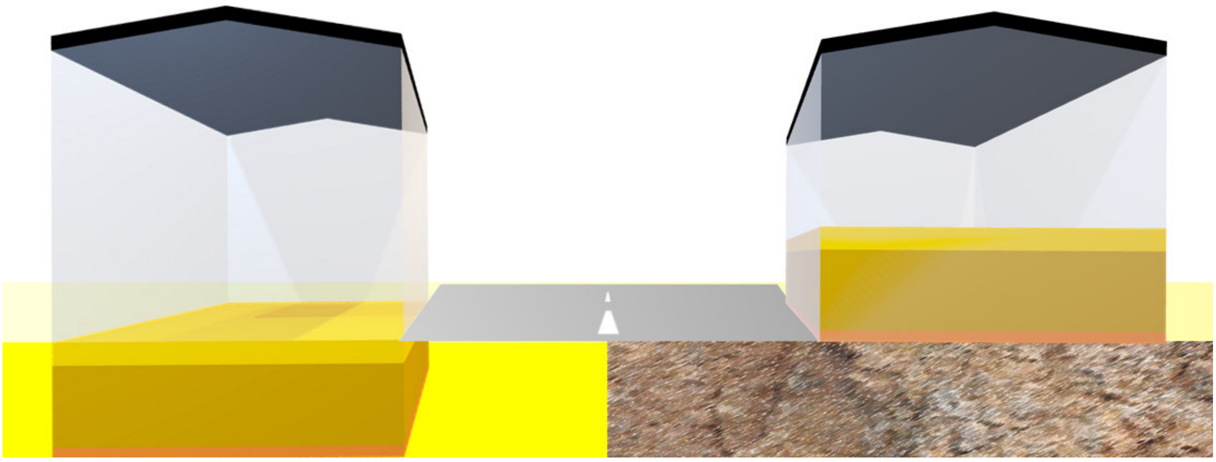


Source: after https://www.fritsch-international.com/fileadmin/_processed_/csm_Grafik_1_02_ae6b67aa24.png

[1] https://www.fritsch-international.com/sample-preparation/applications-solutions/details/solution/characteristics-of-sand-and-criteria-for-its-comminution/

Both processes result in a distribution mainly consisting of coarse silt (63 µm – 20 µm), medium silt (20 µm – 6.3 µm), fine silt (6.3 µm – 2 µm), but also small amounts of coarse clay (2 µm – 0.63 µm). Thus, 5 minutes of grinding in a planetary ball mill can turn sand into a sand-silt-clay composite which could build a base for an artificial Chernozem-like soil type.

After separating the corresponding soil fractions, they get filled into the basement of the SE, starting from clayey or loamy layers up to the silty and sandy layers. This SE actually will be a standard greenhouse of at least 60 square metres in size. If the ground is too stony or too dense to be replaced by the milled sand-silt-clay mixture, the single components can also be filled into the SE and thus directly upon such ground or bed rock which would then act as additional non-permeable layer beneath the bottommost clay layer:



Where possible, basements also can be planked with wood. By this, the stability of the SE can be increased. Also, this lining could serve as an additional barrier for nutrients leaking out or pests and pollutants infiltrating the closed environment. Furthermore, this wooden lining itself works as an additional long-term fixation of carbon dioxide.

The SE's roof will be equipped with solar cells which shall provide enough energy for running the air condition as well as all other electrical devices needed. In European regions, a solar module of 1 sqm size can produce 200 kWh per year[2], or more[3,4]. Given a roof size of 60 sqm, the corresponding solar modules could provide a total of 12 MWh/a. Due to the much higher radiation in tropical zones, these 12 MWh/a could be achieved in shorter time or with less modules. Accordingly, modules can be arranged in a way, that sun light still can pass the roof and reach the plants inside the greenhouse.

Adjacent to and also conjecting the SEs, there will be full-size solar roofs of 60 sqm size each. We speak of that combination as an 'extended solar greenhouse' (ESG) since every greenhouse shall have at least one adjacent full-size solar roof. By this, the ground beneath will be shadowed constantly. And this will provide sheltered space for people to work or meet, but also for supply routes from or to all the SEs:

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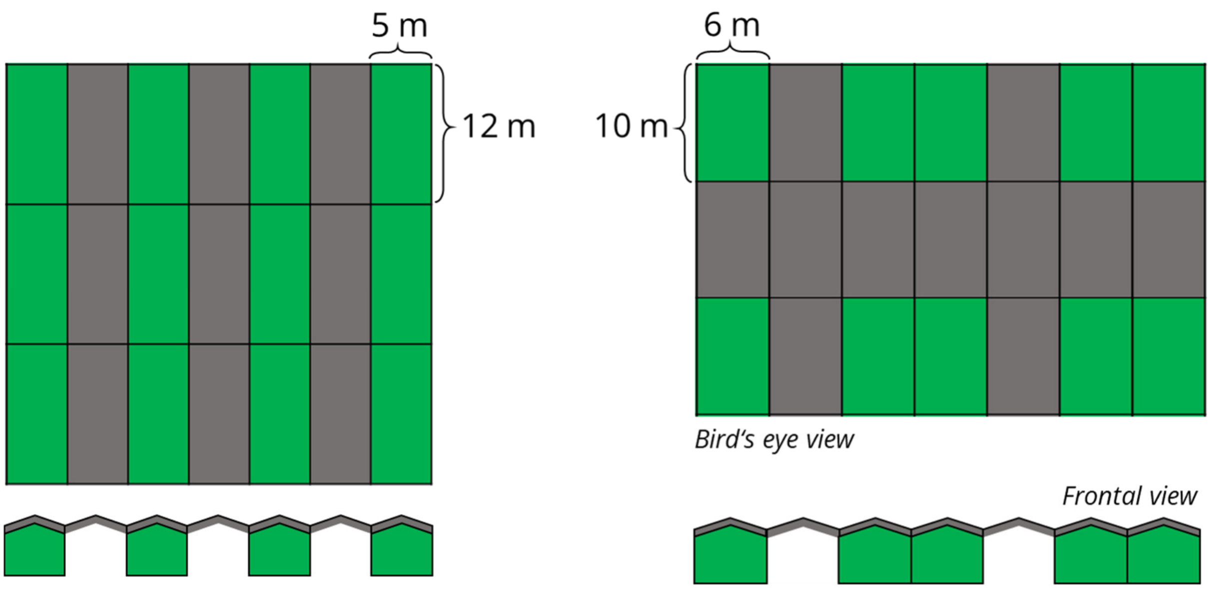
[2] https://pv-held.de/wie-viel-strom-produziert-1m2-photovoltaik/ (German only)
[3] https://globalsolaratlas.info/
[4] https://www.solarempower.com/blog/how-much-power-do-solar-panels- produce/



The solar cells will not only provide the energy for running any lighting and measuring devices, but also for the irrigation and air conditioning system. Furthermore, the energy shall drive a seawater desalination plant which is to provide freshwater for irrigating the plants.

<u>Main Impacts</u>

The basic concept addresses the following problems:

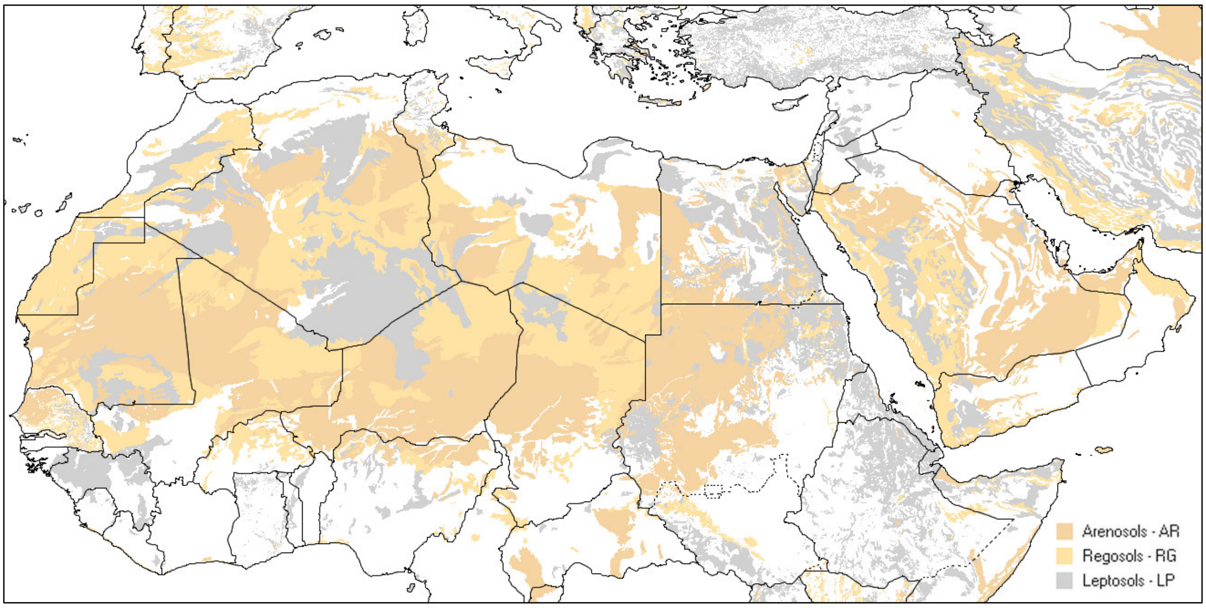
1. Roofs of solar cells will absorb highly intensive sun radiation
   a. which would heat up the atmosphere above ground otherwise, and
   b. which provides a source of free and sustainable energy in areas with little or no firewood.
2. Roofs of solar cells will provide the power to run the greenhouses
   a. which will host plants which absorb carbon dioxide to mitigate climate warming, and
   b. which can grow crops as a reliable source of food in highly degraded or even devastated areas.
3. Solar energy will also run the seawater desalination plant
   a. which provides freshwater for irrigation but also for the local population living in the driest areas of the world, and
   b. which shall also be used to filter microplastics out of the waters gathered from the sea surface in coastal regions.
4. Greenhouses provide working spaces for several types of personnel
   a. which means an additional source of income for locals, and
   b. which necessitates a divers schooling and educational system.
5. Any surplus of energy or crops can be sold to the open market and thus be an additional source of income.

Prototypical Realisation

The Sahara Desert is the biggest arid area in the world, and south of it, its adjacent Sahel region is prominent for hunger crises, poverty, civil wars and, hence, for several waves of forced migration and displacement. Consequently, the Green Deserts project also aims on mitigating these problems: having food and water, having work and income, having the chance to gain knowledge and to be a valuable part of a society build the base for a strong and stable community worth working and fighting for.

Since the Green Deserts concept bases on the usage of desalinated seawater, initial test sites should preferably be located near the coast. Accordingly, sites in Western Africa like Western Sahara or Mauretania would be best. Unfortunately, most the political systems in North Africa are more or less instable[5]. For instance, the Western Sahara is actually annexed by Morocco while half of Mauretania is designated as prohibited area due to criminal gang and terroristic activities[6].

According to the Food and Agriculture Organization's World Reference Base[7] as the international standard for soil classification, most of Northern Africa consists of mainly three different soil types which can also be found in Saudi Arabia or the United Arab Emirates:



Source: Excerpt of the Harmonized World Soil Database v1.2[8]

Thus, if no safe testing ground can be provided in Northwestern Africa, these regions could be corresponding replacements. This is even more true since both countries have become rich as members of the Organization of the Petroleum Exporting Countries. Hence, setting up a test site in one of those would be ideal to test the Green Deserts concept as a future successor program if fossil energy sources come to an end. Furthermore, the technical and personal infrastructure in these countries is already existent. Thus, the realisation could be supported by already technical experienced personnel and enterprises. Accordingly, it could start almost immediately if the necessary funds are available which maybe could even be provided by these countries partially.

[5] cf. https://fragilestatesindex.org/analytics/fsi-heat-map/
[6] cf. https://www.gov.uk/foreign-travel-advice/mauritania (as of date of 30 March 2024)
[7] cf. https://www.fao.org/soils-portal/data-hub/soil-classification/world-reference-base/en/
[8] https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/harmonized-world-soil-database- v12/en/

Outlook

12 MWh/a does not sound very much. But this is only for a roof size of 60 sqm. Thus, adding more and more roofs will result in a tremendous amount of energy. For example, the annexed Western Sahara region covers an area of about 266,000 km^2, or 266 billion sqm. Divided by 60, this results in more than 4.4 billion roofs, or solar greenhouses. Multiplied by 12 MWh/a, this offers the potential for more than 52,800 billion TWh/a. According to the International Energy Agency (IEA), the world's overall electricity consumption has reached a new high in 2021 by an amount of 26,500 TWh[9]. But since the trend in energy consumption is still and still climbing, there is an urgent need for such new clean, sustainable, and free energy. This is even more true when having in mind that more and more countries try to switch from petrol-driven vehicles to e-Mobiles.

Covering today's hunger for electricity would 'only' need an area of about 135,000 square kilometres. This is actually around the size of countries like Bangladesh or Tajikistan, or as shown before, half of Western Sahara. Of course, not all of these ESGs have to be established in one single country. Thus, the Green Deserts concept is ideal for almost all the North African countries. The Sahara Deserts spans an area of about 9 million km^2 which is more than 30 times the size of Western Sahara. In addition, there could be plants of ESGs in all the American, Asian and Australian desert regions. Accordingly, some of the greenhouses of such plants worldwide could be turned into living spaces for scientific or technical personnel or, even better, locals in need of shelter. If those become skilled by corresponding educational programmes, they can look after the neighboured ESGs and the technical infrastructure like the seawater desalination system.

One might think, seawater might be a limiting factor. But we find the opposite being true. For simplicity, take a 1,000 mm per sqm as a very high yearly rainfall in temperate regions. Multiplied by 9 trillion sqm, it would necessitate a 9 trillion m^3 of seawater for irrigating the whole Sahara Desert. Divided by a sea surface area of 362 trillion sqm, this would result in a subtraction of a 9/362th metre of the sea surface which is around one single inch per year.

Hence, instead of waiting for all the polar ice to melt, we suggest to start subtracting an inch of the current sea surface layer to immediately start terraforming desert regions into fertile farming grounds which store carbon dioxide, produce food, and provide work and income for creating or fostering stable and safe communities worth living in and for. Furthermore, by lowering the current sea level in an appropriate manner, we could also mitigate or even prevent flooding events in coastal regions and also along inland streams. Therefore, we would also reduce the costs resulting from compensating damages caused by high waters.

In addition, if most of the desert regions in West Africa could be covered and protected from getting heated up by intensive solar radiation, we could also have a chance to mitigate the effects of hurricanes striking the Caribbeans and the East Coast of the United States of America[10]. This is because dry and hot winds like e.g. Calima and Scirocco are often born over the Sahara Desert[11].

Thus, in our humble opinion, the Green Deserts concept is one of the most promising strategies for mitigating global warming as well as local problems all over the world. Further information on our conceptual designs can be found on our project's webpage[12].

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[9] https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20consumption&indicator=TotElecCons

[10] cf. Historical Hurricane Tracks (noaa.gov)

[11] https://www.star.nesdis.noaa.gov/GOES/floater_band.php?stormid=AL102020&band=GEOCOLOR&length=24

[12] https://green-deserts.net