Halophytes/Saline Water/Deserts/Wastelands Nexus

Subjects: Water Resources
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Climate change is rapidly exacerbating and adding to major-to-existential issues associated with freshwater availability and utilization. The massive, thus far untapped saline/salt water/ocean—wastelands/deserts—Halophytes resources nexus can, at scale and profitably, provide major climate change mitigation and greatly alleviate most extant freshwater issues. Approaches include ocean fertilization and saline/seawater agriculture on deserts and wastelands to sequester massive amounts of CO_2 and methane and for food, freeing up some 70% of the freshwater now utilized by current agriculture for direct human use. This also enables the production of huge amounts of biofuels and biomass-based chemical feedstock employing the massive capacity of cheap saline/seawater and cheap deserts and wastelands.

Keywords: halophytes ; seawater agriculture ; CO2 sequestration ; climate mitigation ; droughts

1. Water/Land Issues

About 97% of the planet's water is saline/salt water. This includes oceans, seas, some lakes, and saline aquifers, many of them large. Seawater has some 40 elements to fertilize plants and trace minerals needed for human health, which are often depleted from arable land [1]. As humans have been pumping what started out as mostly freshwater aquifers, many of these are becoming more saline, and using them for irrigation has increasingly salinated "arable land". Some 2.5% of the water is freshwater, with some 68% of it tied up in glaciers, 30% in groundwater, with most of the rest in permafrost and the great lakes, Lake Baikal [2]. Little of the planet's water is "available" freshwater. Of that available freshwater, 70% is utilized for agriculture/food, 15% for industry, and 15% for households. Due to the current prevalence of freshwater agriculture and the human health needs for freshwater, except for ocean fisheries, oceanography, and seawater flooding, the major focus of water concerns and research has long been concentrated on freshwater. The availability of freshwater is a major determiner of the value of land for various purposes. A huge percentage of the land, over 40%, is deemed to be deserts and wastelands [3] and valued much lower than "arable land". However, deserts/wastelands often have sizable saline aquifers, such as the Nubian aquifer in North Africa, and many are near seacoasts with access to seawater. Also, much of this low-cost land has sunlight for solar energy generation. There are proposals to generate solar energy in the Sahara for use in Europe. Increasingly low-cost solar energy could be used to pump saline and seawater for sizable distances for irrigation of saline/seawater agriculture. Overall, even before climate considerations, freshwater scarcity was of increasing major importance, involving serious resource levels to provide freshwater availability that was pure enough to drink and for agriculture and industry. As the population has increased and the amount of freshwater has not, the considerable efforts and technology needed to provide for an ever more populous society have increased in scope and cost. More recently, the increasing impacts of climate upon freshwater, especially droughts, are resulting in a situation where drinking water and freshwater agriculture are increasingly imperiled, a serious-to-existential societal concern, including from an econometric perspective.

2. Halophytes

There is another option for agriculture, food, and much else that is at a vast scale. The scale of climate, low cost, posits serious profits and has massive upsides—Halophytes. These are "salt plants", plants that can grow/thrive using saline/salt water and salinated land. There are up to some 6000 halophyte varieties covering nearly all freshwater plant functionalities—food, fodder, biomass/energy, wood, landscaping, CO_2 sequestration, wildlife habitat, and, in addition, land desalinization [4][5][6][7]. There has long been a saline agriculture in India for food and fodder [8]. Many nations are developing, experimenting, and conducting research on halophytes. There are dry land halophytes and ocean halophytes. Algae, seaweed are halophytes. In general, ocean and water plant halophytes are more productive than land halophytes. The lowest cost water halophyte approach is open water, sans land, ponding, etc. expenses. A particularly interesting open water region for wet halophytes would be the Gulf of Mexico, utilizing the continent-sized nutrient stream from the Mississippi River efflux. "Ocean Fertilization", where iron-rich dust is used to fertilize microalgae for atmosphere CO_2 sequestration in the ocean, is a form of seawater agriculture. The resultant algae blooms create profitable amounts of protein and lipids for food and energy and much-increased fish populations. For dry land halophyte farming test plots using sandy soils over decades, there has been evidence of little salt buildup if some 35% or so additional [salt] water is used in irrigation to flush the salt into the soil. Halophytes can sequester up to some 18% of their CO_2 uptake in their deep desert roots. Studies indicate that Halophytes can remove some 4 metric tons of CO_2/hectare [9] and, in their roots, sequester approximately 0.7 metric tons or more. The immense capacity/scale of halophyte agriculture [97% of the water, some 40% of the land], along with low cost, available technology, cheap land and water, and profitability, proffers the possibility of literally "greening the planet" to rapidly remove atmospheric CO_2. The Earth's land mass is some 13 billion Ha. If Halophytes are planted on 40% of the land mass, which is wastelands and deserts, and irrigated with saline seawater, they could sequester nearly 4 gigatons of carbon, which is an appreciable fraction of the additional amount emitted. However, not all dry lands are suitable for halophytes. Halophytes can provide profitable bio land and sea CO_2 sequestration uniquely at the scale of climate. Switching to halophyte saline/seawater agriculture for food would free up increasing amounts of the 70% of the freshwater now used for conventional agriculture, solving many to most of the freshwater issues, including climate-induced droughts. Halophyte biomass provides massive amounts of biofuels and chemical feedstock inexpensively. Since seawater contains many plant nutrients, fertilizer requirements are lower. Then there are the trace minerals in seawater that are needed for human health and are being depleted from arable land. There are now approaches in development that enable plants to extract nitrogen from the air. If, as an example, halophyte seawater Ag were to be practiced on the Sahara, the seawater irrigation would create an unstable atmosphere and produce freshwater rain downwind, possibly increasing freshwater resources in the Middle East, which might aid in region stabilization and also reduce the desertification of the sub-Sahara. These huge resources, saline, salt water, deserts, and wastelands, enabled by halophytes, could conceivably largely solve land, freshwater, food, energy, and climate problems profitably at scale. Perhaps the last large-scale planet resources that have not yet been utilized by society. It would also enable productive use of arable land already salinated, including some 25% of irrigated lands [10]. Halophytes cover the product spectrum—seeds, fruits, roots, tubers, grains, foliage, "wood," oils, berries, gums, resins, and pulp and are rich in energy, protein, and fats. Wastelands/deserts particularly suited for Halophyte Ag include Western Australia, around the Arabian Sea/Persian Gulf, the Middle East, the Sahara, and the Southwest U.S., including West Texas and the Atacama in South America.

3. Ocean Fertilization

Ocean fertilization involves adding micro and macronutrients to the upper ocean to enhance algae growth and increase the biological pump for ocean CO_2 and methane sequestration to mitigate climate change [11][12]. The most effective approach utilizes iron micronutrients. Trace amounts of iron, 1 kg, fixes some 100,000 kgs of carbon [12], particle size is less than 1 micron. Issues include efficiency, lowering ocean O_2 levels, altering usual phytoplankton species, and reducing biodiversity. The concerns are apparently, "we just do not know enough", vice, "we know there is a problem". At sea experiments where iron-rich dust was put overboard, and the area monitored indicated algae blooms, as expected, with subsequent fish population increases in some cases. For CO_2, iron enables algae photosynthesis. Algae take up CO_2 and use carbon for skeletons, which drop to the ocean bottom. Ice cores from before the last ice age [13] indicate both extremely low atmospheric CO_2 and Methane and some factor of 4 to 7 greater atmospheric density of iron-rich dust than today. The supposition is that there were droughts that caused extensive iron-rich dust to be blown off the land out over the oceans [as happens today from the Sahara, etc.], which resulted in significant CO_2 and methane sequestration, serving as a contributor to an ice age, along with earth tilt. Apparently, at scale, ocean fertilization could significantly mitigate current climate change. Fans operated by solar energy on near-ocean wastelands could be set up to increase the current [reduced] passive aeolian transport rate of iron-rich dust over the oceans. To counter the Dust Bowl, we planted winter wheat, which reduced the transport of iron-rich dust over the Atlantic. The Asians, in part, planted winter wheat also, which reduced iron-rich dust transport over the Pacific. That, plus the relatively recent increased ocean CO_2 uptake, which is turning the oceans into weak carbonic acid, has reduced the algae populations and consequently reduced algae sequestration of CO_2 and methane. That is, we are currently in an "unnatural" state wrt iron-rich dust and algae populations; ocean fertilization would correct this. Salable products include algae, sources of protein and lipids [food and fuels], and fish that eat the algae.

Given the ongoing necessity of resorting to fish farming/reductions in open ocean fish populations/the health benefits of omega-3 fats/the dearth of protein sources, and the adverse climate impacts of many of the current protein sources, these markets should be motivational/profitable.

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