Solar Thermo-Powered Desalination Fountain-Barge: A Macro-Imagineering NA Venezuela's Golfo de Cariaco

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Abstract: Based mainly on the Fourier Law valid for parallel material layer temperature gradients, a massive floating seawater desalination macro-project almost entirely covering the Golfo de Cariaco, NE Venezuela, is proposed. The purpose of the geographically-scalable unsinkable *Fountain-Barge Desalination Factory* (FBDF) formed chiefly of composite metal foam is bulk freshwater production then to be utilized domestically for commercial crop irrigation and urban population maintenance and increase. Brine reject from the huge FBDF could allow 21st Century development of a commercial aquaculture industry during a potential local encompassing region BS_w Koppen Climatic Classification change as well as adjacent southern Caribbean Sea changes [1].

Key words: Freshwater production, aquaculture industry, solar thermal-powered desalination fountain-barge.

Resumo: Com fundamento na Lei de Fourier, válida para gradientes de temperatura em camadas paralelas de material, propõe-se um macroprojeto flutuante de dessalinização da água do mar cobrindo quase inteiramente o Golfo de Cariaco, NE Venezuela. O objetivo da *Fountain-Barge Desalination Factory* (FBDF), geograficamente escalável e formada principalmente de espuma de metal compósito, é a produção de água doce para ser utilizada em residências, em irrigação comercial e demais aplicações da população urbana. A rejeição de salmoura da grande FBDF poderia permitir o desenvolvimento, no século XXI, de uma indústria de aquacultura coetânea à potencial transformação da região de BSw Koppen, assim como às mudanças adjacentes no sul do Caribe [1].

Palavras-chave: Dessalinização da água do mar, indústria de aquacultura, barcaça-fonte termosolar.

1. Introduction

The relative scarcity of freshwater compared to the Earth's super-abundance of seawater has fostered the investigation of many abstruse technologies for removing salt from seawater as a centuries-old human quest via Macro-Imagineering to amplify reliable and well-regulated regional freshwater supplies. Fountains are a source of both refreshment and joyous renewal [3]. Greenhouses afford constant shelter from all kinds of weathers for commercially valuable plants, decorative or edible; at one locale in the Old World's southern Spain landscape ~270 km^2 are presently enclosed contiguously by sealed glass-houses growing tomatoes and other commercial crops controllably; the effect of the sunshine-reflecting landscape-cover of glazing is to cool the local climate whilst protecting all plants grown within from radical short-term air

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temperature excursions [4]. A floating solar thermal-powered desalination fountain-barge (FBDF) built atop an open 640 km^2 body of seawater, Venezuela's Golfo de Cariaco, Figure 1, might be composed of a plurality of prefabricated, standardized rectangular, composite metal foam modules rigidly locked together in a continuous side-by-side relation and anchored so as to rest on a very large area of swell-quelled gulf seawater. These modules will not require Cathartic Protection. GEOGRAPHOS supposes a maximal freshwater FBDF product annually to be ~0.57 km^3 predictably derived from a FBDF solar distiller empowered by a ~640 km^2 solar energy VANTA-black receiving surface which ultimately causes 2.5 liters/m^2 of freshwater to be made during near-Equator sunny days. The multi-level moored FBDF, unencumbered by shading obstacles above, can be expected to revolutionize freshwater supply (quantity and quality) and use within the Koppen Classification BSw Tropical Semi-desert that completely surrounds Golfo de Cariaco. The contiguous hill and mountain reliefs restrict the gulf's precipitation catchment but might serve as lookouts for enthralling vistas appreciated by national and international tourists appreciating the gulf's monumental anthropogenic facility scenery. Modern solar thermal-powered desalination first commenced at the Las Salinas factory (1872-1912), which generated 4.0 liters/m^2, in desert-coast Chile and various brine and seawater evaporator devices with significant-sized distilled freshwater outputs have operated in Venezuela since circa AD 1930 [5].

2. "Drinking Watershed": Un Unexamined Mega-Infrastructure

A statement of opportunities for enhancement of freshwater supply infrastructure in Latin America ignored recently-developed desalination technology [6]. During the 21st Century, NE Venezuela can become the essential national region contributing vital drinking freshwater withdrawn from Golfo de Cariaco seawater using a gigantic industrialized thermal energy-powered mechanism, the FBDF which abides by the Fourier Law, for the region's agriculturalists and potable water guzzling urbanists . More than a century old [7], pressure-driven membrane desalination is, currently, the most preferred means of manufacturing freshwater from a seawater "Drinking Watershed" resource [8]. Mega-scale floating desalination plants for Spaceship Earth have been proposed previously, although never before on the spatial scale as the macro-imagined FBDF! Admittedly and unavoidably, the FBDF concept has a starkly characteristic aura of a young child's paracosm — a self-created imaginary parallel world — as, for example, the puzzling but stimulating observed fact that crewmembers aboard the interstellar space-travel vehicles associated with Star Trek television episodes and films never, ever worried about their personal freshwater source; no actor/actress is ever seen repairing a freshwater-fountain [9]! GEOGRAPHOS apprehends its FBDF proposal as a "Grand Design" [10] which, if constructed and successful, would correlate its operational product, artificial freshwater, and its encompassing Venezuelan arid landscape. The Koppen BSw Tropical Semidesert Climate of the entire ~400 m-high Araya Peninsula and the heights of the ~800 m-high topography Eastern Interior Range bordering the latitudinally-elongated Golfo de Cariaco requires irrigation all year for commercial crop farming.

On gulf's southern flank, the Pan American Highway [11] parallels the Golfo de Cariaco, following a route traversing its southern shoreline north of the Eastern Interior Range's foreland, potentially allowing the FBDF, with or without a remarkable viewable urban skyline, or even be entirely invisible from both shorelines due to Earth's curvature, to become an infrastructure signed by place-marketers, transnational aquaculture boosterism, waterfront development and de-development, perhaps even a unique tourism floating attraction named after some

globally-recognized Latin American celebrity (of course, toponyms can always be altered to adhere to evolving popular sentiment about faddish and eventually outdated identifiers) ! With its modularized, linked foamed-metal base, the buoyant FBDF might attractive to persons nowadays exclusively dwelling ashore to its offered futuristic living and working accommodations as well as themed entertainment features primarily because it will be isolated from any major future effects of too-familiarly destructive regional earthquakes (think rentable apartments, leasable condominiums, owned single-family residences stacked decorously atop a vibration-free, noiseless movable desalination barge-fountain floating man-made island [2]). Because of its components and sturdy naval construction, the FBDF is earthquake-proof and unsinkable — that is, there can never be an installation failure (the unacceptable difference between expected and observed buoyant platform's module performance)! It is safely foreseeable that only very small, technically-isolatable and extinguishable fires could pose a life-threatening menace to people, pets and personal property.

3. Un Uncertain Future

Chapter 14 of H. Michael Tarver's The History of Venezuela (2nd Edition, Greenwood, Santa Barbara CA, 2018, 248 pages) carries the same title as this Section. But, the brief statement is generally true of all human-manipulated things, alive and/or organizational and seems inapplicable, or at least inartful, when taken as a prospectus conclusion relating to ever-changing Venezuela. Macro-Imagineering ought to play an increasingly useful role in helping Venezuela's 21st Century citizenry (32+ million persons, 89% of whom are currently urbanized) to progress technologically and economically. Many bays of Venezuela's coastline seem adaptable for additional non-electricity consuming FBDF-type installations, so it is surely the case here that GEOGRAPHOS randomly selected Golfo de Cariaco, situated in NE Venezuela abutting the Caribbean Sea, as a suitable demonstration of the unusual "Drinking Watershed" macro-project concept that is quite independent of present-day landscape topography, including past planned or unplanned terrain changes thereof [12]. (Envision 11,800 km^2 blank-slate State of Sucre available for remodeling by its 900,000 + human population, nearly 300,000 of whom live in the State's seaport-capital Cumana City, established under another toponym in AD 1515. It is the oldest Spanish settlement on the New World mainland).

The truly singular composite metal foam FBDF installation bearing a glassed-in distiller, atop ~4,347 km3 of Golfo de Cariaco seawater separated from the Caribbean Sea by a 55 m-deep seafloor sill officially-dubbed the "Salazar Sill", Figure 2, located northwest of Cumana which could be geometrically modified to reduce or increase the present-day Golfo de Cariaco tidal range of 10-20 cm, could cover ~2.13% of Venezuela's declared 30,000 km^2 national water territory, enduring future higher mean air temperature than 26-27^oC and mean wind-speed of >4.0 m/s. Cumana receives ~250 mm of rainfall annually. Therefore, the prevalent BSw climate encourages the anticipation of some wind-power and solar-thermal power enterprises focused on, and in the vicinity of, the State of Sucre's central geographical feature, the Golfo de Cariaco! Within a Nation hampered by an ongoing electricity shortage mega-problem, NE Venezuela has difficult-to-master landforms as well as an aridic regional climate affected by pronounced latitudinal fluctuations of the Earth-atmosphere's Intertropical Convergence Zone that, so far, still restrictively inhibits, or even retards, developmental pace of the region's early-21st Century vigorous socioeconomic development.

Major earthquakes and subsequent tsunamis have had a profound impact on the Golfo de Cariaco for

many thousand years. The earliest Spanish-reported tsunami in Venezuela, in AD 1498, occurred at Boca de la Sierpe, Pedrenales. Some geoscientists strongly support the geohistorical opinion the 1498 AD temblor first opened the Gulf of Cariaco to massive seawater intrusion [20] and the opening event-process was furthered later by the seismic catastrophes of AD 1530 and 1543 AD and, perhaps, then completed by a large-scale seafloor displacement on the sill's western face at the gulf's entrance. Little of the available and thoroughly examined published geological evidence is actually conclusive on this specific sediment slump timing subject [21-22].

4. Geographical Summary of the Present

The Golfo de Cariaco east of Cumana City is a semi-enclosed ocean sub-basin hydrographically affected mainly by the present-day wind regime affecting northeastern Venezuela [13]. Unintentionally Cumana City was sited and continues to be maintained on the dangerously active 800 km-long right-lateral strike-slip El Pilar Fault which formed the whole gulf in its existence as a visible geomorphic surface trace for accommodative relative motion along the Caribbean-South American tectonic plate boundary. During the most recent Ice Age low-stands, the Golfo de Cariaco was disconnected from the world-ocean and sometimes functioned as a freshwater and/or saline lake basin. West of the gulf, the Cariaco Basin is the largest anoxic basin of Venezuela's submarine continental borderland, in our world second in volume only to the notorious Black Sea [14-15]. Venezuelans have promoted the inundation of some segments of the Nation's 2,800 km coastline — that is, ~0.4% of the Earth's — by their petroleum mining: since AD 1929, the 12,000 km^2 Maracaibo Lake located in northwestern Venezuela evidenced induced lakebed subsidence of >5.5 m caused by that extraction of valuable liquid and gaseous materials. Dredger deepening of an oil-tanker shipping lane by AD 1956 increased ocean seawater flow into Maracaibo Lake [16]. Future sea-level rise must, therefore, subject both Maracaibo Lake and the Golfo de Cariaco to greatly increased openness to non-placid marine influence [17]. Indeed, the Nation's Caribbean coast is constantly subject to Trade Winds and, episodically, to hurricane storm surges and tsunami-generated waves. Since circa AD 1950, agricultural landscapes of the Caribbean Sea Basin have suffered a drying trend as well as a few multi-year droughts — for instance the 2013-2016 AD drought was universally judged as very severe, putting at risk ~2.0 million people because of food production insecurity and slackening tourism [18]. Even the diminishing fishery annual take has apparently been affected by commonly observed climate change [19].

5. Solar-thermal Fountain-Barge Desalination Factory (FBDF) Particulars

Established incrementally — modules added to the "initiating rectangular barge kernel" as propitious financing permits — the composite metal foam FBDF has the potential to become a picturesque tourist industrial desalination factory venue additional to many other already extant famous attractions of the State of Sucre, Venezuela. For example, tri-cable detachable gondolas, each carrying ~35 passengers, moving at 30 km/h, passing support towers spaced 3,000 m apart, could afford visitors fine, inspiring elevated and long-distance views of the stationary FBDF from the Araya Peninsula and the Eastern Interior Range hillsides. Possibly the cable-supporting towers — executed in some recognizably Venezuelan architectural style — could be designed also to remind people that Cumana City is/was an industrial seaport containing ships and waterfront cranes. Of course, such a cableway would have to be constructed so as to endure expectable major earthquakes and remain always in a safe condition of workability! The use of super-cables formed of graphene might be advisable too. In the event of necessity — such as a reasonable

tsunami warning — the cableway might be beneficial to the citizenry and tourists as a method for rapid evacuation of low-elevation high-risk wave run-up danger zone landscapes. Serious strong temblor disasters seem to be repeated sporadically on, approximately, 130 year cycles meaning that long time-periods elapse before similar recurrences. All structures intended for disaster mitigation and post-disaster recovery inevitably are subject to expensive maintenance costs and, therefore, ought best to be used daily. The specific weight of seawater may be taken to be 10.09 kN/m^3 or 1.03 t/m^3; a general operational rule is that it is necessary to have a breakwater if the significant wave-height is >4 m. As a result of the major temblor of AD 1530, Cumana City was totally swamped, and all its infrastructure converted into worthless rubble by serial 7 m-high tsunamis! Ideally, this fact indicates that resettlement of the human population currently at considerable risk ought to be accomplished; however, practicality and finances surely intervene in this instance, necessitating instead other pragmatic real-world actions. Abandonment of some unprotectable at-risk strand properties should be considered carefully by responsible local authorities and concerned citizens. Would thousands of willing former Cumana residents, assured of their safety during future tsunami event-processes, live permanently aboard the solar-thermal composite metal foam FBDF? (YES!) Kiyonori Kikutake (1928-2011), the Japanese proponent of marine metropoles — that is, self-sustaining, flexible, clean, safe communities — under the rubric of Metabolist Architecture was only able during his lifetime to complete one tiny example, the Okinawa Ocean Expo in 1975 AD as the only Metabolist Architecture floating macro-project: as a social group, until circa AD 1970, Metabolist architects planned to transform Tokyo Bay into a body of seawater supporting a floating metropolis extension of old Tokyo.

But, what is the alluded GEOGRAPHOS macro-imagined FBDF?

Floating all solar-thermal FBDF components on a spatially-vast captive composite metal foam barge infrastructure decouples the installation from seismic disturbance because the linked rectangular modules floating base-isolation structure prevents relative shifts of all FBDF components aboard [22]. Any damaged edge-modules can be removed for timely repair or if the sea-surface space is needed for other “Grand Design” purposes in future. The FBDF’s constant position in all circumstances with respect to the seawater surface, whatever its position at any specific time or sea-state condition, facilitates boats and ships to come along-side in the same manner as usually done with fixed piers and berths. From AD 1995 until 2001 AD, macro-engineers tested technologies inherent in a Mega-Float airport (with a 1 km-long runway) in Tokyo Bay, Japan, which is subject to tsunamis of remarkable size [23]. “Closed cell metal foam was first announced in 1926 by M.A. DeMeller in his French Patent 615,147” [24].Composite metal foams are lightweight, reduce collision penetration and can cope with fire temperatures twice that of the metals of which they are comprised [25]. Robust metal-ceramic foam forms a part of the hulls and superstructures of many boats and ships already afloat upon the world’s mutable ocean as well as our planet’s navigable lakes and rivers [26]. Since such foams are cellularized (enclosing empty voids or trapped gas bubbles by >50%), the Fourier Law of thermal transmission by conduction between various materials or layers of material, and convection, according to the values of heat resistance or surface thermal resistance owing to the convection currents generated applies rigorously. The surrounding Golfo de Cariaco dryland is an appropriate region for the confident operation of the effectively high-performance and low-cost desalination factory entailed by the composite-metal foam FBDF. Industrially simple, the interfacial one-Sun (1000

W/m^2) solar contactless steam/vapor generation by photon management and heat localization FBDF, operating at 100°C and ambient air pressure, raises the possibility of stable and ultra-efficient daytime-only solar-thermal Golfo de Cariaco seawater desalination [27-28] (see Figure 3).

The pervasive fabric photon-absorber, normally situated beneath the overhead slanted glass-house as a VANTA-black flat defect-free carpet affixed to the deck of each FBDF module, is the key technology for the proposed FBDF freshwater factory. The dark-colored fabric reflects ~0.035% visible spectrum sunlight [29]. The Serpentine Gallery Pavilion in London, England, designed by Peter Zumthor as a uniformly black-box artwork situated in a vast expanse of naturally green grass owned by London Kensington Gardens, existed for three months during AD 2011 [30]. VANTA-black is almost impossible for the human eye to perceive the shape of any object and structure coated by the light-absorbing pigmented spray-painted carrier solution: Asif Khan unveiled a pavilion at the Pyeongchang Winter Olympics Games held in South Korea during AD 2018 as his version of our world's darkest 35 m by 35 m building. (Pyeongchang, South Korea is typed as a Koppen Climate Classification Dwb, a humid continental climate). Anish Kapoor's Descent into Limbo (1992) was displayed until 6 January 2019 at the Fundação de Serralves, Museum of Contemporary Art in Porto, Portugal. Suggesting a cube-shaped building inside of which is a lit, circular 2.5 m-deep real hole coated in black-pigmented paint, thus presenting an illusion to its parade of temporary viewers of a depthless ground cavity. Sadly, during August 2018 a 60 years-old Italian man fell into it and was injured! From a close or distant vantage place, the FBDF might appear to be a sparkling crystalline structure, but its interior would have an entirely different impressive visual effect: maintenance personnel must be wary as they carry out their duties inside the Fountain-Barge Desalination Factory! GEOGRAPHOS supposes some infrastructure add-ons might be required if the FBDF installed at the Golfo de Cariaco. Reject brine produced by seawater flushing of the accumulated particles of salt resulting from the FBDF's operation as a distiller may need to be managed using a method quite different from those usually employed [31]. From a trough-like collector along the keel of the FBDF, a slightly self-buoyant plastic hose may be used to convey the brine wastewater westwards toward the lip of the "Salazar Sill". Released through a pendulous hose's directive nozzle, the dense brine fluid would naturally flow by gravity down the western slope of the sill and, thusly, be transported for ultimate disposal into the anoxic Cariaco Basin. Humbly, GEOGRAPHOS recommends that Venezuelan regional planners please consider the FBDF as a potentially viable 21st Century infrastructural option for their Golfo de Cariaco segment of the New World's "little Venice" [32].

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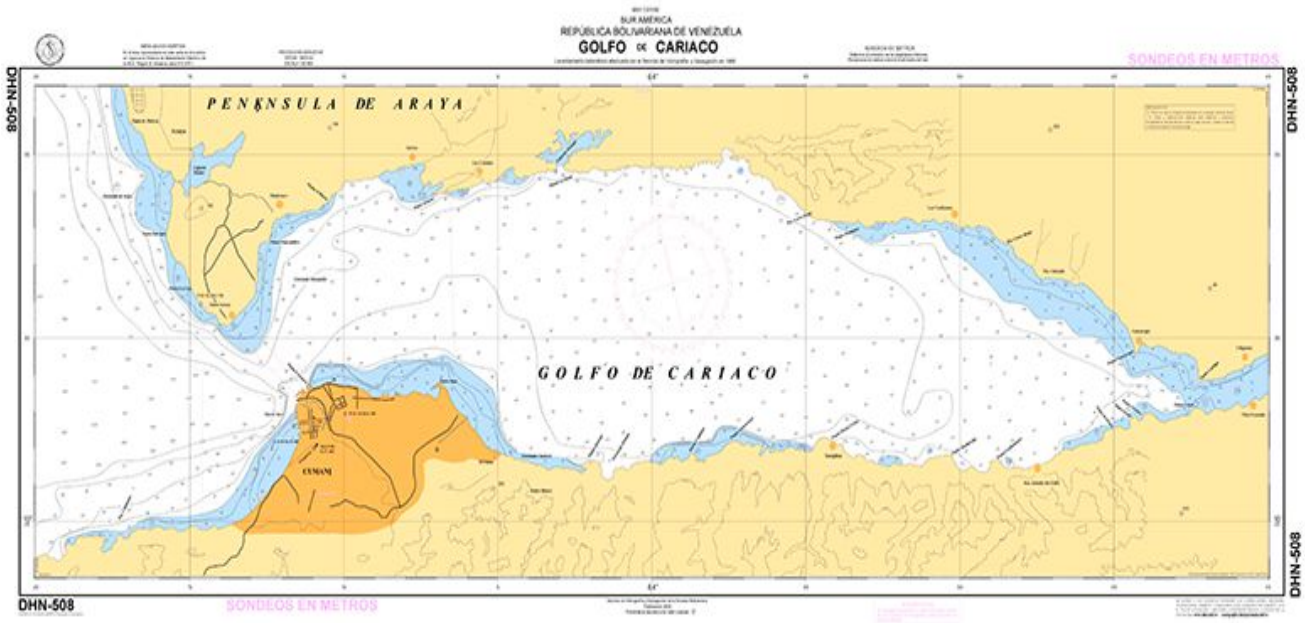

Figure 1. Authoritative Venezuelan armed forces navigation chart of the Golfo de Cariaco.

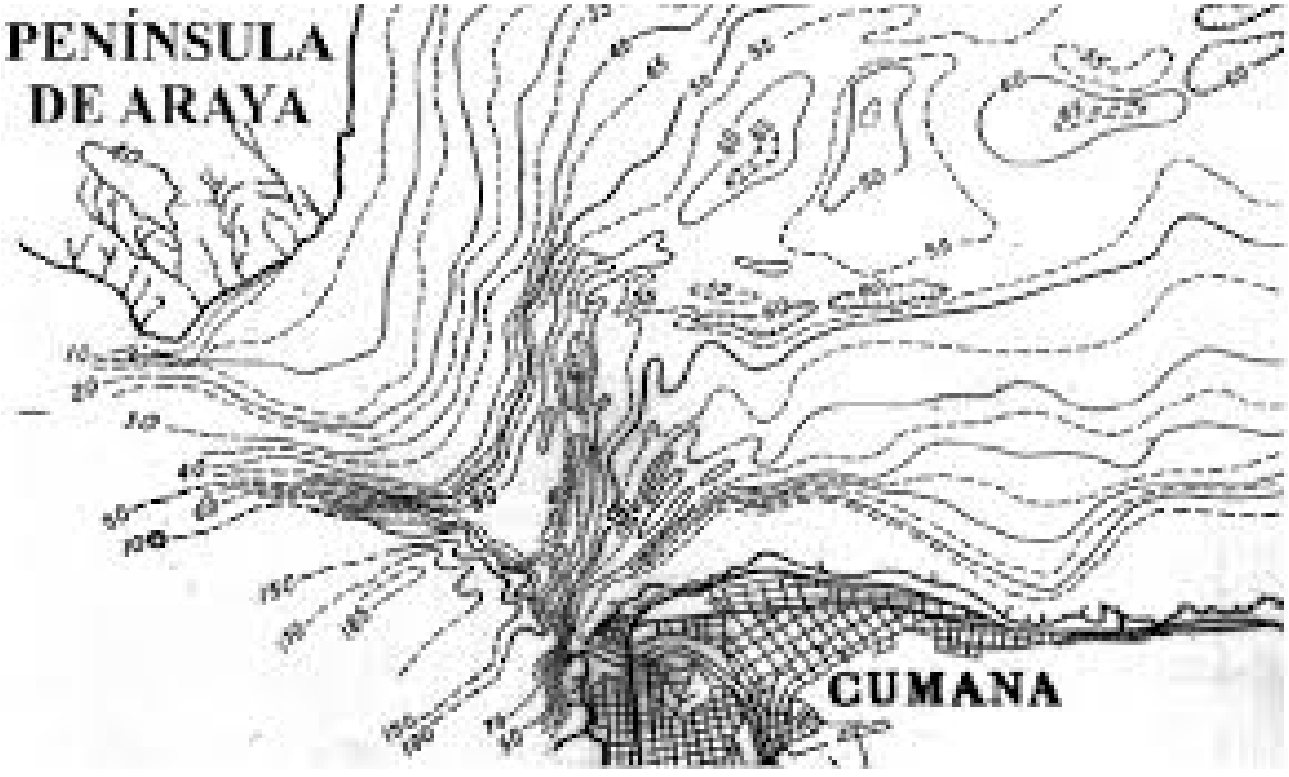

Figure 2. Entrance/exit of Golfo de Cariaco illustrating the "Salazar Sill". Source of data and author(s) unknown. Notice the unfortunate tsunami-vulnerable geographical siting of present-day Cumana City.

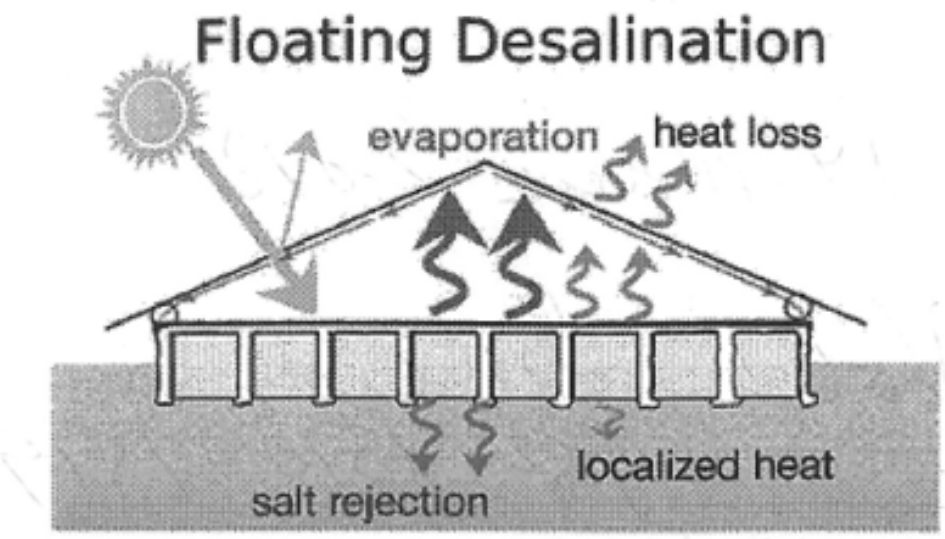

Figure 3. Schematic diagram of the FBDF module.