

Towards sustainable landscape irrigation using novel design of water collecting systems from atmospheric humidity condensation

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Article

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Abstract

The paper proposes an innovative improvement to the water collectors from atmospheric humidity condensation by introducing non-hydrophobic substances to speed up the water condensation and the dropping off process using simple technology, inexpensive and with high quality materials with the finality to favor sustainable irrigation in regions characterized by water resources scarcity favoring greening generally. The innovative collector' design and experimentation conducted confirm the possibility to collect water from air humidity in different regions with reduced rain days as semi desertic zones enhancing the gain of desertification process, harvesting water in urban landscape, in vertical greening and roof gardens. The first principal innovative aspect of the novel design collector is the fast capacity of condensation caused from the method of design of the used materials and fast capacity of releasing water collected to contrast the undesired evaporations. The second innovative aspect is the reduced volume to permit a diffused and unexpensive implants which can be distribute suitably on the targeted landscape. Reduced costs and simplicity of fabrication announce real possibility of use in underdeveloped and poor countries to increase vegetation diffusion firstly and contributing on sustainable agriculture and architecture.

Introduction

Water scarcity is one of the most prominent problems facing the countries of the world, especially in light of global warming and low levels of precipitation, which makes the water harvest in the form of rainwater collection and the creation of water condensers that transform the fog and water vapor suspended in the atmosphere an urgent necessity, In light of this, many efforts have been activated in water harvesting, especially in countries that suffer from a great water scarcity, such as some Mideast and African countries. The condensation of water vapor from the atmosphere, converting it into drops of water, collected to satisfy many purposes of irrigation and the daily human use. any experimentations in this sense were done and the issue has a consolidated literature encourages the research in this field. The propose of this paper is to introduce innovative elements to permit a large diffusion reducing costs firstly and increasing the capacity of these implants. United Nations classify water as the main issue of a sustainable socio-economic development, Water, standing to United Nations reports climate change mitigation and resilience has the core that colligates society and the environment [1] United Nations. (2018).

This research combines technical development and improving the novel design of water collecting systems with existing experimentation and relative literature. The novel aspect is related on the reduced and variable dimensions, the introduction of advanced materials and physical principles that govern the condensation process. Basic science demonstrates that the dew point of the vapor of water in an environment depends on several elements that must be satisfied at the same time: the presence of water vapor and decreasing of temperature and smooth surfaces. The continuous desertification of potential agricultural areas and landscapes in semi desertic Countries as Jordan induces us to think on how to improve sustainable systems characterized by reduced costs and simplicity of construction to permit a

real diffusion. These systems should be used in many modes as urban landscape irrigation, mini agricultural activities and to irrigate trees in zones characterized by real difficulty to irrigated. The proposed systems do not need manutations and are ideated to be passive systems without any carbon footprints. Together strategies that focuses on classifying natural types of vegetation diffused in very hard climatic zones to be employed in greening recovery in Jordan and other semi desertic countries. Collecting vegetation types and their persistence to hard climate constitute the first step in fighting desertification in sustainable mode and is based on observations related to natural characteristics of some suitable vegetation that among the years demonstrated a high capacity of persistence in very hard conditions. The use of this type of vegetation could produce many benefits as relaying the process of desertification, stabilizing landscape, giving the possibility to some cities to have sustainable urban greening. The low cost, the unneeded maintenance and the introducing passive irrigation favor the access of developing countries on environmental policies that contribute actively on reducing the global warming and desertification processes.

Literature Review

The most famous effort related to develop systems able to harvest water from air humidity is the Warka Arca project developed by Arturo Vittorio with his team by designing a water harvesting unit called (Warka Water Tower) which the main function of it is to harvest the water by the atmospheric humidity absorbed by a surface called mesh so that could help providing the community of 100 liters of water per day. the tower mainly consisting of a polyester mesh supported by Bamboo frame (Fig 1), this mesh could catch the humidity and condense it to gain a waterdrops (Fig 2) which fall into a reservoir found at the bottom of the structure and a fabric canopy could shade the area around it and used by people to set under it.

The efficiency of this type of network is reduced and causes the loss of a quantity of accumulated water is the rebound of the drops that accumulate on the net with the flowing air. Many researchers tried to improve the efficiency of the net and develop its parts efficiency. Four factors that determine the efficiency of the humidity collectors, which are: wind velocity, liquid fog water content, droplet size distribution, and net characteristics [2] Warka Water Inc. (2017).

In different regions researchers developed projects and devices with targeting on harvesting water from air humidity, these devices use the universal principle of densification. Dehumidifiers utilized as water extraction devices distributed on different areas in Bahrain confirmed the economy of this method of water collection in comparison to other nonconventional methods [3] (Nidal A. Dahman et Al. 2017). These systems are active once to allow the water vapor densification among the use electric device that aspire and reduce air temperature shows the importance of this type of research for some Countries.

Different typologies of collectors presented in Hasila Jarim et Al. 2020 [4] are characterized by large dimensions with several problems related to the use of the mesh and difficulties related to the degradation of parts of collectors, (see Table 1). Various types from traditional passive implants (without the use energy) to those designed in active mode certificate their importance and the need of

development their potentiality. At now it is impossible to imagine their large use firstly for the elevate costs and to technical difficulties of production and installation. The targeted proposed design in this paper is based on the use of micro applications that permit large range diffusion [5] (Aldeek ZAO. 2020).

Table 1. Selected fog collector design. Source:[4].

The fog collector	Size/design	Type of application	Advantage ratio	Maximum water collection (liters/day)	Country
Warka Arca	Circular tower with radius of 5 m and 13 m height	Limited installations	Use the high level of air humidity by absorption	100 liters to 500 liters	Ethiopia and central Africa
Electrical condensers	Different dimensions	Limited	Need power supply and manutentions	20 liters to 200 liters	Oman
Eiffel collector	4×8×0.3 m metal frame, two separated layers of Raschel 50% net with 10 additional stripes in between	Large scale experiment	A 3D collector that is advantageous for places with no unique wind direction associated with the occurrence of fog.	2650 l per day during the peak fog season.	Peru
Harp collector	2×4×0.3 m metal frame, 2256 m of 1.5 mm rubber string vertically installed	Large scale experiment		200 l/day during peak season	Peru
Diagonal Harp collector	2×4×0.3 m metal frame, 1520 m of 1.5 mm rubber string diagonally installed	Large scale experiment		94.2 l/day during peak season	Peru

The use of advance paints and materials could contribute at the realization of new types of collectors using their high absorbance and condensation performance of water vapor. The use of advances materials and paints find applications in many sectors enjoying large literature and use in architecture, engineering and in biomedical studies to prevent many problems as humidity in walls, internal healthy environment, self-cleaning and the formation on viral or bacterial agglomerations or to release disinfectant substance. [6], (Dragoş Rădulescu et Al 2016) [7]. (Aldeek & Al. Khateeb 2020).

Discussion

As mentioned in literature review the topic enjoys large interesse and presents a potential tool to harvest and collect water in those Countries with scarce water resources. The challenge in this paper is to transform traditional collectors in novel water collecting systems that permit a capillary diffusion, reduced costs and volumes alloying their simple management. The importance of developing this type of technology its contribution in many life sectors: obtaining potable water in these zones where water sources are exposed to high level of pollution or diffused infections, contributing to a micro agricultural system in remote regions, incentivizing the stop of desertification in many semi-arid regions and finally giving a valid contribute on climate change. For many years' attentions are focused on mega projects in emerging Countries as motor of sustainable development forgotten that the sustainable development

must take into consideration the diffused and capillary production in remote regions. The result is the continuous internal and external immigration. Micro projects that use advanced technologies but simple to be understood and actuated present the base for the recovery strategies in many sectors, [8] Aldeek ZAO, 2020.

The proposed novel design of water collecting systems is based on this idea and concept, it uses simple methodology combined with advanced materials to provide portable implants which can be easily managed. As will be explained in successive parts of this work we focused on major comprehension of factors that govern the condensation and dropping process, it is necessary that materials used in the construction of our novel water collecting systems correspond to some criteria as:

- High capacity to exchange heat rapidly with surrounding environment, (high heat emissivity).
- Presents smooth surfaces to favor the verification of the dew point, (Wettability).
- High capacity to release the collected water rapidly to contrast evaporations, (hydrophobic performances).
- Use suitable design configuration that favor the process of densification and collecting.

NOVEL DESIGN OF WATER COLLECTING SYSTEMS FROM ATMOSPHERIC HUMIDITY CONDENSATION

The structural and surface characteristics of the proposed collector must reflect the above-mentioned performances. The proposed water collector model consists of the main elements represented by the collector net responsible for condensing the droplets carried with wind or fog that lends through the network, and a water tank centered at the bottom of the model. The major element of design in the proposed system is to change materials used in the classic nets. Since now we must specify that atmospheric conditions play important role in the design process, it is possible to classify environmental conditions in three types: high mountains characterized by diffused and continuous wind and fog, hot humid zones characterized by high level of saturation (high humidity and temperature) and arid and semi-arid zones characterized by summer-night dew formation. The indicated zones have as commune element the low level of precipitations due different reasons. Traditional elements used in hot-humid zones have not the capacity to transform humidity from gas status into liquid one. As shown in Figure 2 classic materials absorb humidity from atmosphere this means that works in just high level of saturation. The time for this process is long and reduce sensibly the capacity of the net to collect water. While traditional elements used in very high mountains are designed for the specific geographical conditions and cannot function in semi or arid zones.

The novel system must combine other performances of the used materials, as shown in Figure 3 a solid surface has major capacity to attract humidity from the atmosphere. This capacity is referred to physical principles related to the conditions of the dew point verification. The solid surface as the anodized aluminum or other metal elements, (see Table 2) lose heat rapidly respect the environment satisfying the first condition, the smooth surfaces generally satisfy the second dew point condition.

The above-mentioned conditions are necessary to be employed in the realization of our novel system. Figure 4 presents the concept of realization. The introduction of metallic elements increases the quantity of water collected because together the absorption of water as in classic meshes because adds the water quantity collected by the dew point verification. Adding to these metallic elements a hydrophobic capacity we will reduce the evaporation loss of collected water on the net.

The innovative part is the design of the grid' surface and the introduction of a hydrophobic performance obtained by the use of substances as nano ceramic, liquid ceramic or other suitable paints. The Nano Ceramic which has the advantage of not interacting with water and it does not alter the properties of the materials with which it is painted, its function is only to accelerate the fall of the droplets after condensation.

On the other hand, the materials used in the novel design of water collecting systems must reflect the desired performances. It can be classified in three steps, the first the high capacity of absorption and wettability, the second the high capacity to lose heat in manner that favor the condensation rapidly. The third is the capacity to release the accumulated water rapidly. Last element but not the least is the design' configuration of the proposed systems, a mesh disposed in horizontal mode do not benefit from gravity to release condensation rapidly, the very smooth surface does not attack the surface tension of the water droplets for example.

4.1 WETTING PHENOMENA AND THERMAL RADIATION CAPACITY

Wettability and super-wettability happen once a water drop is placed on a surface, it forms a sphere or wets the surface completely and called "super-wetting". Antiwetting and super-anti wetting are the capacity of a surface to release water drops formed by condensation process [6] (Durand et al., 2011). Wettability and anti-wetting have particular importance when studying phenomena related to heat transfer and humidity applications generally. In our case these concepts guarantee the functionality of our novel system. The high wettability in our case is guaranteed from the selected materials having high capacity to lose heat by radiation (heat emissivity).

The process of wetting phenomena is related to thermal radiation capacity which standing to the Stefan-Boltzmann Law [9] (Nelly Durand et Al 2011), compared with the radiation of heat from an ideal "black body" with the emissivity coefficient (ϵ) = 1. the emissivity coefficient (ϵ) for some common materials can be found in the Table 2. It is note that the emissivity coefficient (ϵ) for some materials varies as environmental temperature are changed [10].

Table 2. *Thermal Radiation Capacity-Emissivity Coefficient (ϵ) [10]*

Material	Emissivity coefficient	Material	Emissivity based on 26.85 C Emissivity coefficient
Alumina, Flame sprayed	0.80	PVC	0.91 - 0.93
Aluminum Commercial sheet	0.09	Plastics	0.90-0.97
Aluminum Anodized	0.77	Wood, Pine	0.95
Asphalt	0.93	Wrought Iron	0.96
Black Body Matt	1.00	Black Epoxy Paint	0.89
Black lacquer on iron	0.83	Glass smooth	0.92 - 0.94
Paper	0.93	Black Silicone Paint	0.93
Clay	0.91	Oil paints, all colors	0.92 - 0.96

Table 2 shows the emissivity of some materials at 26.85 C. The emissivity expresses the capacity of certain material to lose heat resulting colder than the environment. This propriety determines the possibility of the condensation on the surface in question. At lower temperatures from zero to 26 grads C the behavior of surfaces may be different. To understand better this aspect, we conduced some Laboratory tests which consists in exposing different materials with same geometric measures without altering the bulk density to zero C temperature and with environmental temperature 26 C in the same method and time of exposing. Measuring their surface temperature in progressive time intervals in this way materials that reach faster the equilibrium with surrounding environment will result the better than the others because have the highest level of exchanging heat at low temperatures, (see Table 3).

Table 3. Thermal Radiation Capacity at low temperatures based on Laboratory tests (Source the Author 2021).

Material 5X5 centimeters with thickness 0.2 mm	Temp. After 1 minute	Temp. After 10 minutes	Temp. After 20 minutes	Temp. After 60 minutes	Material	Temp. After 1 minute	Temp. After 10 minutes	Temp. After 20 minutes	Temp. After 60 minutes
Smooth glass	0	7	15	26	PVC	0	7	14	25
Not treated Aluminum	0	3	10	20	Plastic	0	7	14	25
Aluminum Anodized	0	6	13	24	Wood	0	6	14	25
Iron	0	7	15	25	Oil painted surface	0	7	14	25
Asphalt	0	7	15	26	porcelain	0	7	15	25
Black lacquer	0	6	14	25	Black Epoxy Paint	0	7	15	25

The capacity of the selected material for construction of the proposed system depends on its wettability, availability, and durability.

4.2 HYDROPHOBIC PHENOMENA

The industrial applications of superhydrophobic performances are a consolidated reality especially in field of paints production. These applications noted as: anti-fog coating, anti-freeze surfaces, oil and water separation, anti-bacterial surfaces are applied in medical and industrial camps to prevent bacterial

accumulation and to improve performances against corrosion of metals and implants. [11] (Gh. Barati Darband et AL. 2020). Hydrophobic phenomena consist in anti-wetting surface capacity to prevent water accumulation. In nature, the lotus effect means that water drop on a lotus surface showing contact angles of approximately 147° (cutting angle) caused from the surface configuration [12] (Latthe S. S. et AL. 2014).

Lotus effect describes the behavior of the superhydrophobic surfaces where water contact angle is greater than 150° with low sliding angle, under 10° . Attract important research interest related to the potential anti-icing properties. Applicability in daily life issues, in agriculture, and in many industrial processes as: antiadhesive coatings, self-cleaning materials, antifouling, anticorrosion, [13] (L. YU et AL.). The use of superhydrophobic paints and other industrial applications as the use of nano ceramic on surface simulates the lotus effect and can be easily used in the proposed system.

The Innovative Design Of The Grid' Surface

The proposed prototype takes into consideration difficulties to achieve water harvesting from humidity directly. Major difficulties of the dew point verification related to particular conditions as shown in Table 4 which determine specified temperature, specified relative humidity level and particular surfaces. As success in particular types of vegetations that benefits from humidity absorption during night hours. These vegetations resolve the problem by the continuous leaf reduction of temperature caused from their morphology, and by the direct absorption of humidity mixed in air see (Fig. 7). Generally, as shown in Fig. 7a leaf has two different surfaces the upper is characterized by smoothness favoring the condensation while the lower is characterized by a rough one to maximize the dew absorption from nearest air.

This concept is also explained by Alfred W. Bennett "Although gardeners universally maintain that growing plants have the power of absorbing water through their leaves, both in the liquid and the gaseous form, in addition to the power of suction through the roots,". In his "Text-book of Botany" (English edition, p. 613),[14], Sachs says: "When land-plants wither on a hot day, and revive again in the evening, this is the result of diminished transpiration with the decrease of temperature and increase of the moisture in the air in the evening, the activity of the roots continuing; not of any absorption of aqueous vapour or dew through the leaves" [14].

These two positions seem to be in contradiction about the method of absorption of dew and water vapour from air but evidence that it is possible to absorb dew and water vapour from air and the difficulty of trees to benefit from the collected water by leaves. In fact, when we study some particular trees, we note that the collected water by leaves is canalized and directed into the three roots. From both affirmations we can benefit in our novel collector design in manner that surface of parts used in the condenser realization must be designed to reflect this aspect. From our research suitable materials as metallic strips, strips of cooked clay and plastics constitute basic elements for the condenser

construction. To satisfy the absorption and dew condensation together it is necessary to use a multi-layer strategy. The level of relative humidity and day temperatures determine the construction type of collector.

However, from experimentations we noted that the use of the clay could be satisfied in different levels of temperature and relative humidity due to its high performance to absorb and to favor dew condensation. It is noted the high capacity of cooked clay and ceramics in general to absorb water due to the presence of micro canals (porosity) which ensures the dew and water vapour absorption. On the other hand, ceramics generally, do not release the absorbed water easily. This aspect leads that the use of special paints will be the way to optimize the process in our novel collector (see Table 4).

Table 4
Water Absorption-Condensation Materials Performance

(Source the Author 2021).

	Anodized Aluminum	Ceramic	Semi-cooked Ceramic	Dried Clay	Wood	Iron
Absorption for cubic centimeter in 30 minutes	0.0%	34%	50%	60%	20%	0.0%
Condensation in grams for square centimeter at 26 C' with relative humidity 60%	0.77	0.95	0.90	0.90	0.93	0.96

Table 4 and chart 1 show that materials which satisfy both conditions of absorption and condensation at the same time are ceramic derivatives. This fact changed the initial hypothesis to use just metallic. The first prototype is realized from a structure that supports the metallic strips, see Fig. 8. Experimentations confirmed that the prototype in Fig. 8 has a very good functionality in summer season where the formation of dew accumulation and sensible temperature daily reduction are very frequent.

Table 5
comparison between types of collectors and the proposed novel collector

(Source the Author 2021).

Type of Collector	Construction method	Working method	Notes	Climatic zone application
Warka Arca	Vertical very high structure with cotton mesh	Absorption from very high relative humidity	Due dimensions cannot be diffused. Works only in humid regions. Cannot achieve humidity in cold seasons.	Humid and hot regions
Harp	Horizontal large dimensions. Mesh realized from finest metallic files	Resistance to wind rich of fog and condensation carried by wind	Target destinations limit its use in just very high mountain zones.	Very high regions above 2000 m over sea level.
Eiffel	Vertical large dimensions. Mesh realized from finest metallic files	Resistance to wind rich of fog and condensation carried by wind	Target destinations limit its use in just very high mountain zones.	Very high regions above 2000 m over sea level.
Novel Collector 01	Vertical or horizontal mix mesh metallic and cotton mesh.	Resistance to wind rich of fog and condensation carried by wind	During cold seasons absorb humidity from air. During hot seasons condense humidity. Limited dimensions and could be constructed in different methods and materials.	Semi and arid zones
Novel Collector 02	Horizontal exposed surface	Attraction of dew condensations	Could be used in variable dimensions and materials to collect dew and week rain	Semi and arid zones

5.1 FIRST PROTOTYPE CONSTRUCTION AND EXPERIMENTATIONS

Initially the collection mesh consists mainly of intersecting metallic strips with high emissivity (radiative capacity) to lose heat by radiation in manner to favor the condensation process at targeted temperature variations. The surface of these strip is elaborated to favor the anti-witting capacity. This elaboration could be obtained in different modes as the use nano-ceramic paints or to be designed among the introduction of micro canals of the surface using for example the laser cutter performances. From testes we reached the convention that the novel collector must have good performance in all seasons that present scarcity of precipitation in semi and arid zones (from March to November), it is noted that vapor saturation and week rains in these zones are frequent. To improve our initial collector, it is painted with dark color the with the finality to satisfy the targeted function in all seasons.

From testes conducted to determine which materials to be used in the proposed novel system results that the use of a metallic mesh painted with liquid ceramic, nanoceramic, nanographene or any other oil paint could guarantee the targeted performances of emissivity to favor dew condensation. The prototype, thin, is painted with nanoceramic (to favor the anti-wettability performance), which is the commune technology used to conserve cars because results cheapest, easy to realize and does not need maintenance. Tables 2 and 3 shows that it is possible to use a variety of sustainable materials. In our case we selected strips of aluminum for the facility of prototype realization, many other materials should be suitable and can be use with satisfied results as strips of iron or P.V.C or plastics.

5.1.1 PROTOTYPE

The design of the prototype structure takes in consideration the operations of realizations, painting, nanoceramic application and testing. It is realized from light iron structure, (see Fig. 8). The structure can be realized in many other configurations that result more suitable for the targeted uses. Dimensions and shape can be modified in relation to the site where will be installed.

5.1.2 SOLID ELEMENTS ADOPTED TO ACHIEVE THE WETTABILITY

As mentioned in 5.1 longitudinal metallic strips are used to realize the wind resistance net and to attract humidity from air. These strips are disposed vertically to use better the gravity in the water droplets dropping off, horizontal elements are used to organize the net. The nanoceramic application once time completed the installation and painting of the metallic strips net, (see Fig. 8).

5.2 DEVELOPED PROTOTYPE CONSTRUCTION AND EXPERIMENTATIONS

During the experimentation in which was in July 21, in Rihaba (a fraction of Irbid in Jordan) the major dew avenues nearest ground surface which induced to modify the initial prototype in a horizontal one more suitable for this condition. Figures 9.a and b show condensation happing process, the weight of water droplets favor their accumulation near ground. Thus, the final version of the collector must take this aspect into consideration. Note that all condensation on surfaces will be evaporated in few minutes if not collected and finalized.

5.2.1 DEVELOPED PROTOTYPE CONSTRUCTION

From discussion in 5.1 the need of developing other type of collector suitable for weather conditions in the experimentation location. This type offers major horizontal surface to be suitable for the collection of dew condensation. It is characterized by simplicity of realization and low-cost materials. Realized in P.V.C panels which is a high emissivity material (see Table 2). As shown from documentation the novel collector is able to have very good performance. This type benefits from week rains diffused in semi-arid zones contributing if finalized to fight desertification. As discussed before the capacity of condensation

depends by two factors the first is the high emissivity of the collector surface the other factor depends on how the surface releases condensation rapidly to be finalized for spontaneous irrigation, this factor is guaranteed by the anti-wetting capacity of the collector surface. Figure 10 shows the collector function during the experimentation. Figure 10.a shows the initial test, while Fig. 10.b&c show the concept of the final form of the collector. Note that the form could be simplified to be a simple panel for each tree or vegetation. (See Fig. 11).

5.3 TESTS AND MEASUREMENTS

The tests consisted in measuring the efficiency of the system in terms of water quantity collected. We selected three sites: the first is the Yarmouk University in Irbid (Jordan), the second site is the Jordanian University of science and technology in Ramtha (in Jordan) and the third Rihaba (in Jordan) the test duration is 24 hours.

Table 6
Experimentation of the Novel Collector

(Source: The Author21).

Test description Location Rihaba (in Jordan)						
Date	Time	Daily Temperature maxima in C	Daily Temperature minima in C	Humidity level %at experimentation time. (Source: 15	Minim temperature to verify the dew point (as in Table 07) in C	Water quantity harvested (in hour/mq) in ml
10/7/21	5.00 am 6.00 am	32	18	90 ..\humidity in rihaba 10 07 21.jpg	25.1	2000
11/7/21	5.00 am 6.00 am	31	21	90 ..\humidity in rihaba 11 07 21.jpg	25.1	1800
12/7/21	5.00 am 6.00 am	31	21	85 ..\humidity in rihaba 12 07 21.jpg	25.1	1800
13/7/21	5.00 am 6.00 am	30	20	85 ..\humidity in rihaba 13 07 21.jpg	25.1	1900
14/7/21	5.00 am 6.00 am	29	19	80 ..\humidity in rihaba 14 07 21.jpg	25.1	1600
15/7/21	5.00 am 6.00 am	31	21	70 ..\humidity in rihaba 15 07 21.jpg	25.1	1200
16/7/21	5.00 am 6.00 am	32	22	55 ..\humidity in rihaba 16 07 21.jpg	25.1	900

Table 7
Dew point
index

(Source
Author
Elaboration).

DEW POINT INDEX															
		Relative Humidity (%)													
		30	35	40	45	50	55	60	65	70	75	80	85	90	95
Room Temperature (°C)	30	10.5	12.9	14.9	16.8	18.4	20.0	21.4	22.7	23.9	25.1	26.2	27.2	28.2	29.1
	29	9.7	12.0	14.0	15.9	17.5	19.0	20.4	21.7	23.0	24.1	25.2	26.2	27.2	28.1
	28	8.8	11.1	13.1	15.0	16.6	18.1	18.1	19.5	20.8	22.0	23.2	24.2	25.2	26.2
	27	8.0	10.2	12.2	14.1	15.7	17.2	18.6	19.9	21.1	22.2	23.3	24.3	25.2	26.1
	26	7.1	9.4	11.4	13.2	14.8	16.3	17.6	18.9	20.1	21.2	22.3	23.3	24.2	25.1
	25	6.2	8.5	10.5	12.2	13.9	15.3	16.7	18.0	19.1	20.3	21.3	22.3	23.2	24.1
	24	5.4	7.6	9.6	11.3	12.9	14.4	15.8	17.0	18.2	19.3	20.3	21.3	22.3	23.2
	23	4.5	6.7	8.7	10.4	12.0	13.5	14.8	16.1	17.2	18.3	19.4	20.3	21.3	22.2
	22	3.6	5.9	7.8	9.5	11.1	12.5	13.9	15.1	16.3	17.4	18.4	19.4	20.3	21.2
	21	2.8	5.0	6.9	8.6	10.2	11.6	12.9	14.2	15.3	16.4	17.4	18.4	19.3	20.2
	20	1.9	4.1	6.0	7.7	9.3	10.7	12.0	13.2	14.4	15.4	16.5	17.4	18.3	19.2
	19	1.0	3.2	5.1	6.8	8.3	9.8	11.1	12.3	13.4	14.5	15.5	16.4	17.3	18.2
	18	0.2	2.3	4.2	5.9	7.4	8.8	10.1	11.3	12.5	13.5	14.5	15.4	16.3	17.2
	17	-0.6	1.4	3.3	5.0	6.5	7.9	9.2	10.4	11.5	12.5	13.5	14.5	15.4	16.2
16	-1.4	0.3	2.4	4.1	5.6	7.0	8.3	9.4	10.5	11.6	12.6	13.5	14.4	15.2	

Conclusions

The presented novel collector puts together elements of high technology and traditional elements with the finality to increase its efficiency, diffusion and to reduce costs which is fundamental element when dealing with underdeveloped Countries where resources are very limited. Other relevant element that the whole system can be produces locally because does not need complex fabrication. The carbon footprint is reduced to zero, no electricity is required, and all functionalities are governed by the natural lows and physics. It could contribute to different sectors as sustainable agriculture and can help the development of land scape greening in our cities and find application in roof gardens and vertical greening. Satisfying our principal target which to fight desertification and to contribute positively on climate change studying a technology that can be understood and built easily by all.

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Figures

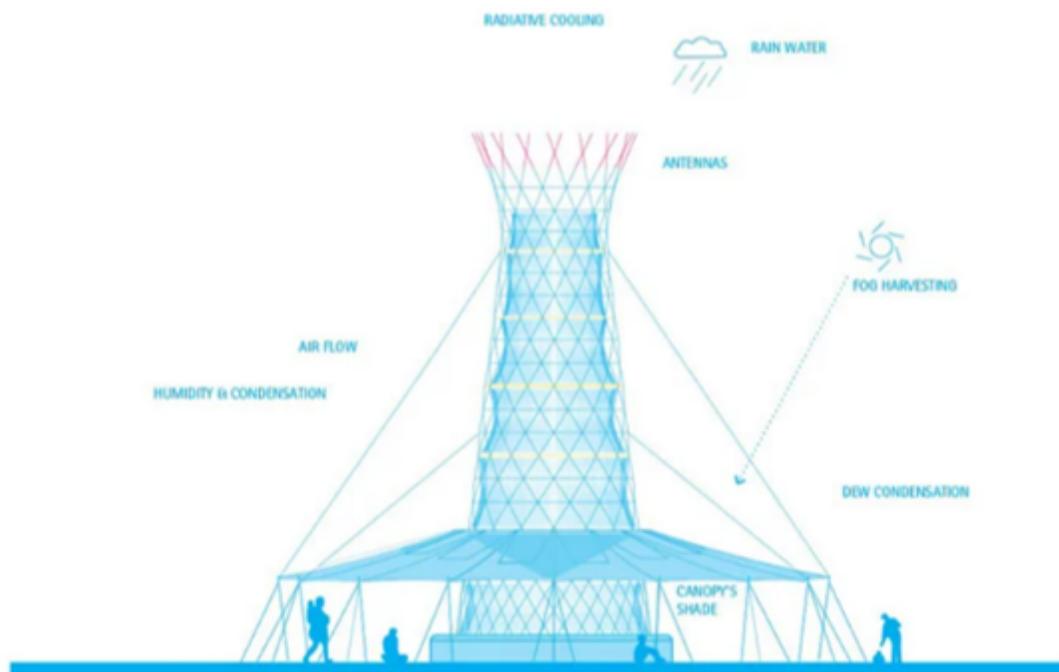


Figure 1

The Warka water details. Source [2]



Figure 2

The water drops condensed against the collector mesh. Source [2].



Figure 3

The water drops condensed against high heat emissivity solid surface. (Source the Author 2021).



Figure 4

Proposed use of elements of the solid surface. (Source the Author 2021).

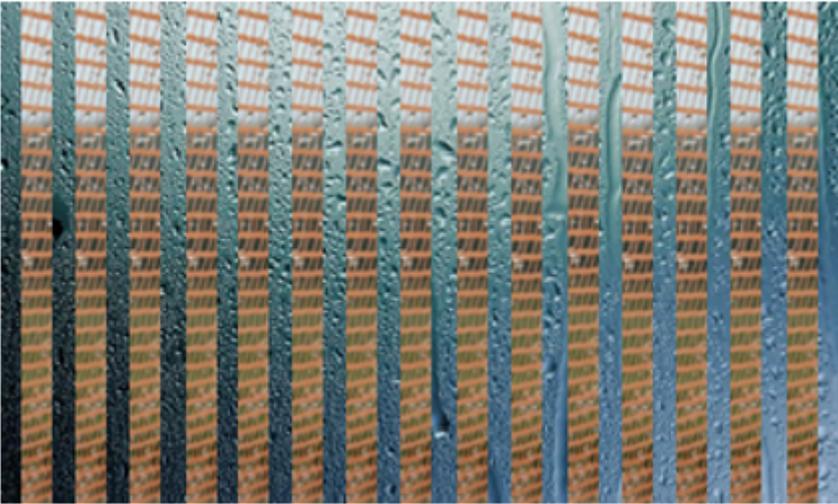


Figure 5

Proposed use of elements of the solid surface in combination of the traditional net. (Source the Author 2021).



Figure 6

The behavior of water droplet of lotus leaf surface. Source: [13].



Figure 7

a. Typical rough leaf surface b. smooth leaf surface. Source: (Source the Author 2021).



Figure 8

First Metallic Prototype used in experimentation. (Source: The Author 2021).



Figure 9

(a, b) Moisture accumulation in low level banks and condensation on metal surfaces. (Source: The Author 2021).



Figure 10

(a, b, c) first experimentations. (Source: The Author 2021).

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