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Campus by the Sea: Adapting the Landscape to Evolving Salinity

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Abstract. A lush green campus has been the American University of Beirut (AUB) flagship for the last five decades. The present decade however, saw the water well bear the brunt of growing population, decreased rainfall, and unsustainable consumption[1]. The bliss of the neighboring sea turned into a curse, as the aquifers fell short, and the extraction overload left the water table brackish and polluted. To mitigate the recently increased salinity, we combined the responsible consumption goal with the experiential education, and the innovative use of infrastructure. Water use awareness drove this effort. Luckily, the water network availed (regarding the plan to segregate the brackish network from the main waterlines). Same for the health system (streamlined vaccination program[2]) and the educational facility (greenhouse/nursery labs) both of which were intrinsic to this collaboration. Returning the greenery without spending too much green!

Keyword:
Innovation in adaptation, SDGs in education, Salinity tolerance, Greenery in brackish settings, Green Metrics Campus

1. Introduction

The American University of Beirut campus is arguably one of the most memorable in the area, comprising a diverse variety of native and exotic flora. The inhouse well sufficed during the past four decades but the new trend in climate change stifled that. The uncontrollable digging of wells due to exploding population numbers and lack of urban planning, resulted in the transformation of many Beirut front wells into brackish water reservoirs[3]. At first, the physical plant department had launched a gradual replacement of salt sensitive hedges with more tolerant ones. Thanks to our comprehensive SDG inclusive planning, a gradual transplantation of salt tolerant species on campus [4] to replace the cover plants requiring fresh irrigation water was already taking place[5]. However, the exponentially rising salinity recently exacerbated the problem. This led to an increased outsourcing of water, which kept the campus verdant but ran a hefty bill. By setting up nurseries using the expertise of the students in plant breeding, we will fast track the program while saving the cost of new saplings, and then use the separate brackish water system to irrigate the new arrivals as they come out of the inhouse nursery. Thanks to our dynamic vaccination program[6], the students will be given priority access to attend to the plants.

2. Rationale

This paper describes the initial campus-wide plan to reduce freshwater use, and the current proposal to fast track the multiplication and transplantation of high salt tolerance varieties. SDGs like life on land, climate action and clean water buttress the core structure of the project, while others influenced the methodology, specifically innovation in infrastructure, and sustainable urban planning both of which intrinsic to the AUB ethos of neighborhood partnership and quality of life improvement. The proposal to replenish the campus with high salt tolerance species allows the sea flora, which had given the Lebanese coastline and Beirut its particular biodiversity since time immemorial, to reconquer a small space long lost to intensive urbanization and population density [7]. Beirut coastline exemplifies the typical karstic propensity of the Lebanese terrain, and is typified by the illustrious Raouche area's Pigeon rocks [8]. The particular karst ecosystem and the accompanying biodiversity survived urbanization to a limited extent in the tiny part of the Raouche area called "Dalieh" [9], but is increasingly bearing the brunt of advancing city building and overpopulation [10]. AUB campus became the default protectorate due to the remaining patch of vegetation, now a rarity in the hottest abode of real estate competitiveness. Beirut has more trees on buildings than on land, and for the most part, it is vegetation aiming to denote a selective lifestyle rather than safeguard the indigenous botanical patrimony. Such advantage provides a much-needed natural extension and vital space for this ecosystem [11]. AUB is also situated in the natural continuation of the karst formation incline and is suited to act as shelter to many inhabitants of the Dalieh ecosystem, especially if the indigenous flora is allowed to thrive. Decreasing the effect of nonindigenous invasion favors wildlife conservation [12] while fitting in a stricter freshwater use policy. The reestablishment of the indigenous ecosystem may even extend to the sea floor, where algal diversity is intrinsic to life below water [13]. Another beneficial aspect of this initiative is the contribution to the quality education SDG by using the expertise of the Department of Agriculture (DAG) to train the students in hands-on plant breeding. The contextual nature of this exercise highlights the concept of solution-based thinking and addressing issues at the regional level, which the program has weaved into its vision and curriculum [14]. The WEFRAH initiative is a WEF nexus based approach aimed to influence policy and create research based solutions [15], it is based in the Faculty of Agricultural and Food Sciences (FAFS) and focuses its vision through the lens of interdepartmental/interfaculty collaboration towards critical solutions in the context of arid and semiarid areas. In this particular project, the collaboration with the Physical Plant Department [16] allowed for the optimal use of the irrigation system, by separating the brackish source and using the inhouse well to irrigate without having to purchase freshwater. The unsustainable practice will otherwise be depleting another aquifer somewhere in the vicinity of the one we can no longer use for freshwater supply [17]. Similar collaboration with the AUB vaccination program allows us to request the fast-track vaccination of the students who will be working in the labs to breed the slat tolerant species we already have on campus, saving funds and benefiting the students through experiential learning.

3. Methodology

A plant survey of AUB campus was completed, and the irrigated areas were analyzed with regards to maximum tolerable salinity. Depending on the plants present in each irrigated patch, an estimate of the current salt tolerance was noted, and a possible replacement was suggested with the aim of irrigating using the inhouse well which variates between 3000 and 5000 ppm. The picture of each to-be-replaced candidate was taken and the new replacement suggested based on similarity, availability and ultimately its tolerance to salinity.

The goal is to irrigate using the inhouse well, without any outsourced freshwater, to save both treasure and another close aquifer use.

Current plots requiring freshwater purchases:

Bermuda Grass patches

Bermuda grass patches are leftovers from the original design and cannot withstand the current well salinity. It is being replaced with St. Augustine grass which tolerates higher salinity but can be further improved by gradually replacing it with high salinity tolerant Phyla nodiflora.

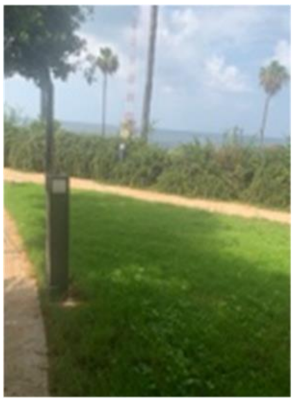

Figure 1. Salt Sensitive Plots: Bermuda Grass

Rosemary hedges

Hanging rosemary tolerates some salinity, but cannot be irrigated directly from our well.

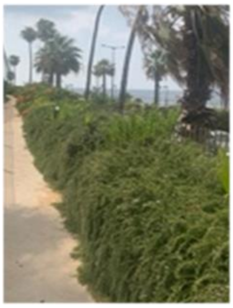

Figure 2. Salt Sensitive Plots: Rosemary

Plumbago:

Plumbago doesn't tolerate high salinity, and although the older hedges do not require irrigation, the recent ones do.

Figure 3. Salt Sensitive Plots: Plumbago

Wisteria:

Wisteria does not tolerate high salinity, and although the older hedges do not require irrigation, the recent ones do.

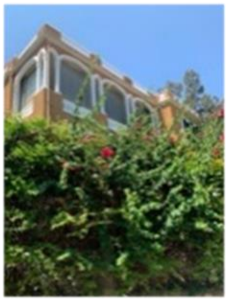

Figure 4. Salt Sensitive Plots: Wisteria

Bougainvillea:

Bougainvillea does not tolerate high salinity, requiring freshwater supply.

Figure 5. Salt Sensitive Plots: Bougainvillea

Current alterations in planting such as introducing moderately tolerant cover crops like Wedelia, and high tolerance plants like Carissa proved successful. Introducing higher tolerance cover grasses along the present ones allow for a gradual transition. That takes into consideration the requirements of the terrain, avoiding sudden soil disruption and unexpected outcomes like diseases or appearance of invasive species.

Current Transitional Plots:

Wedelia and Phyla nodiflora replacing Bermuda grass (fig. 6-9)

Previous Bermuda grass patch is gradually replaced by Phyla nodiflora (turkey tangle) and Wedelia, both of which are drought and salt tolerant. The goal is to irrigate using water reaching 6-7 dS/m EC or 5000 ppm in total dissolved solids.

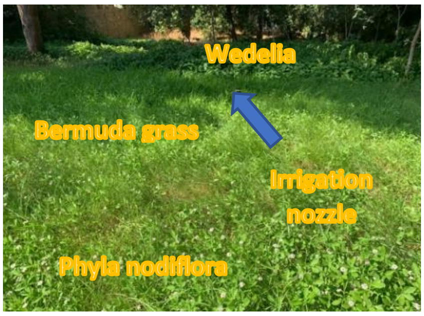

Figure 6. Current Gradual Replacement Plot: Wedelia and phyla nodiflora replacing Bermuda grass

Figure 7. Current Gradual Replacement Plot: Wedelia and Phyla nodiflora replacing Bermuda grass

Figure 8. Current Gradual Replacement Plot: Wedelia and Phyla nodiflora replacing Bermuda grass

Figure 9. Current Gradual Replacement Plot: Wedelia and Phyla nodiflora replacing Bermuda grass

Carissa and St. Augustine grass replacing Bermuda grass (fig. 10-11)

Previous Bermuda grass patch is gradually replaced by St. Augustine grass and carissa both of which are drought and salt tolerant. The goal is to irrigate using water reaching 6-7 dS/m EC or 5000 ppm in total dissolved solids.

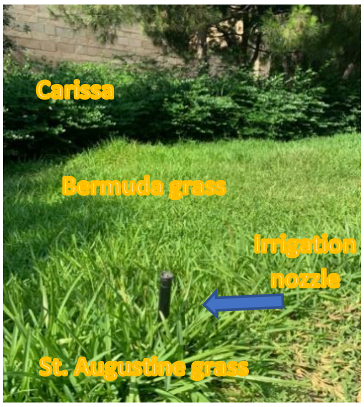

Figure 10. Current Gradual Replacement Plot: Carissa and St. Augustine grass replacing Bermuda grass.

Figure 11. Current Gradual Replacement Plot: Carissa and St. Augustine grass replacing Bermuda grass.

Suggested plots with very high drought and slat tolerance (fig. 12-13)

Currently, many plots contain species that require irrigation with moderate salinity, but replacing one type, in this case Rosemary, would permit less frequent irrigation, while using the inhouse well that can reach 6000 ppm in salinity.

Figure 12. Plot template for very high salt and drought tolerance

Multiplying the plots containing Sea grass and Agave can be done at very low expense at the inhouse nursery. Such plots would tolerate irrigation with up to 9 dS/m EC or 5000 ppm in total dissolved solids, and at a significantly lower frequency in case of drought.

Figure 13. Plot template for very high salt and drought tolerance

4. Results

The current well salinity at AUB is 4000-5000 ppm, which requires the daily purchase of around 400 m^3 of freshwater, to ensure the campus water requirements including irrigation. Swapping the sensitive plants with high tolerance to salinity candidates reduces outsourced water purchase, and the further depletion of another water table in Lebanon. Many current plants on campus are suitable for such a transplantation like the Agave species, Begonia, Phyla nodiflora, Opuntia, Thevetia instead of Plumbago, Bermuda grass, and Wisteria. The cover plant Wedelia although relatively salt tolerant can be replaced with Oenothera drummondii, the beach evening Primrose which is virtually similar in shape. The amount of saved freshwater normally used to dilute the inhouse well salinity would be up to 200 m^3 (50%) out of the 400 m^3 purchased daily in summer for instance.

5. Discussion

The rapidly evolving changes in climate overall, and agricultural variables specifically, like water salinity and availability require fast action. Evidence-based approaches make the foremost basis of SDG focused interventions. AUB campus has survived the gargantuan urbanization/gentrification of Beirut Front. The seaside, like many other Beirut quarters suddenly in demand, found itself in the throes of a of a real-estate boom which often bypassed the proper and efficient urban planning process. The karstic advantage of the aquifers pushed against unsustainable demand finally gave, and Beirut seaside wells turned over their freshwater output to the imminent Mediterranean border, in the form of faulty sewers and routinely clogged gutters. The ambitious botanical transformation of the campus suffered the municipal failure and lost the advantage of self-sufficiency formerly afforded through the inhouse well. The older trees are mostly self-sufficient and many are highly salt tolerant. The cover plants, hedges and many indigenous and endemic varieties depended on the karstic bliss which formerly accorded all the freshwater needed to survive by the sea. The older trees and the ingenious campus architecture shielded the plants from sea spray and inclement salty breeze, while the inhouse well supplied the lifegiving elixir, until its total dissolved solids reached 5000-6000 ppm. The purchasing power of the institution could most likely sustain the freshwater outsourcing required to lower the salinity to 2500 ppm, but it would be contributing to the unsustainable depletion of another aquifer, not too far away. The change of scenery and return of costal flora may end up saving more than water. The continuation of the habitat, downhill from the ecosystem that Dalieh provides a mere mile away, can serve to protect many herptile and insect species that require the seacoast flora, which the botanical makeover does not allow despite its splendor. Many indigenous and endemic amphibians and reptiles are currently endangered [7, 18-20], the return of their natural habitat, by providing the suitable ecosystem would support the hidden lives of underground dwellers albeit at the expense of colorful botanical wonders. The sacrifice may worthwhile however, as the critters we do not immediately notice may well be noticing us, and the diversity may to be prove an essential cornerstone preserving the whole arch above, at an age of incrementally microbe resistance and dramatically receding microbiome.

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