MAKING SENSE #3

# The Sinking Ship: Environmental Degradation and the Precipice of Human Collapse

Throughout history, environmental damage has been one of the most important factors in civilizational collapses. Environmental damage has driven crop failure, starvation and desertification, contributing to the collapse of many civilizations like the Peruvian Nazca, Easter Island, Norse Greenland, the Anasazi, the Tiwanaku civilization, the Akkadians, the Mayans, and the Roman Empire.

Coming down from the mountains in my country of Lebanon, a layer of thick brownish air covers the city of Beirut. It ominously reminds me of the severe smog in London and Los Angeles in the 1940s and 1950s caused by urban influxes and spikes in the number of cars and factories. In Beirut, the smog comes from diesel generators whirring across the country and most recently, toxic emissions due to the burning of carcinogenic low-quality fuel. This pollution of the air we breathe is visually and sensorially overwhelming, and I catch myself wondering whether Lebanon could one day join the sinister list.

After three decades of chronic electricity deficits-from supply shortages, expensive and polluting fuel and diesel oils, non-billing, and a weak grid-the electricity sector in Lebanon has collapsed. State electricity barely provides a few hours per day and the country's cities are dark at night. Under the current disastrous circumstances, heavy particles and carcinogen materials are released into the air, which have increased by 300% wheezing, coughing, and bronchial irritations. Indeed, according to a study done in Hamra, Beirut, back in 2012, the use of diesel generators for only 3 hours/day was the direct reason behind 38% of the daily carcinogen exposure of the residents and so with the diesel generators running nearly for 24 hours, the exposure to toxic pollutants emitted solely by the diesel generators would increase by 8 folds. With all else being equal, this means that the 24-hour operation of diesel generators and the 300% increase in toxic emissions would result in yearly addition of around 550 cancer cases, an estimated 3,000 people developing chronic obstructive pulmonary disease and approximately 500 hospital admissions due to cardiovascular diseases including strokes. It is also estimated that the consumption of diesel generators itself imposes a penalty of a minimum of 8 million dollars for health consequences each year and 9 billion dollars in fees paid by the Lebanese residents. In 2018 alone, the total subscription-based generator market size was approximated at $1.1 billion. Considering the current situation, these numbers are expected to increase by at least 8 folds, totaling around 9 billion dollars' subscription fee that will be paid from the Lebanese residents' pockets.

Vehicles are another major source of emissions in Lebanon. The number of cars per capita (865 cars per 1000 capita) is among the top 5 in the world. It has been reported in 2016 that the number of passenger cars, which makes around 90% of the car fleet in Lebanon, is 1.8 million. These cars travel on average a distance of 12000 km/year which leads to a consumption of ~1107 L per car per year.

This means that a car owner pays $2700 per year on gasoline without considering the wear and tear of the car. Before the economic crisis, a typical Lebanese person earning around $17000 per year spent ~16% of his/her yearly income on gasoline only. According to the IPT report, the gasoline consumption per capita is about 2.7 times more than the world average and 2.3 times more than a citizen of the Arab world.

The 20-years mean average of the aged vehicles, which drastically affects their fuel efficiencies, and the relatively high number of cars makes the emission of these cars contribute to more than 50% of the air pollution in Lebanon. In fact, in 2011, 27.1% of the total direct $CO_2$ emissions in Lebanon were due to transportation. The world average for that same year was 19.7%, which means that the carbon dioxide ($CO_2$) emissions from transport as a percentage of total fuel combustion in Lebanon was 1.4 times higher than the global percentage. Also, a study conducted by Saliba and coworkers assessing the sources of air pollution in Lebanon showed that traffic contributes by 48% to the levels of polycyclic aromatic hydrocarbons, a family of carcinogen compounds originating from combustion.

Public passenger cars and public buses made up only 2.26% of the total vehicle fleet composition. Short term solutions to the public transportation service that was adopted by the government many times is to buy additional buses. Like all spending done by the government, quick solutions never came neither with a pre-well studied strategy nor with a post-monitoring and evaluation plan that assessed the increase in ridership and the improvements of the services, facilities, and urban regulations. In addition, while the drawers of the ministries are filled with studies commissioned by donors and promising the development of a reliable public transportation system, to-date, there are no long-term plans in sight as they have been forsaken since the beginning of the Civil war in 1975. Lebanese can't even dare to compare against giants of public transportation like France, where almost 70% of the people living in Paris use public transportation to go to work. Based on a stated preference survey designed by a team of researchers at the departments of agricultural sciences and civil and environmental engineering at AUB, a cheap service of 1000 LBP (0.67$ at the old exchange rate of 1515 LBPP) would trigger 44% of the population to switch from private to public transport. This would result in 24 million dollars of benefit, and a drop of 35000 tons of $CO_2$ emission per year.

To put it in perspective, any shortage or spike in the gasoline price would cripple the whole Lebanese residents as passenger cars are the main means of transportation. So, it becomes evident that any gasoline shortage would make queuing at gas stations for the Lebanese resident a life necessity and not a choice.

After being left with the choices of either complete darkness or living under the toxic fumes and the humming of diesel generators, they are now left with two hard choices to make: either they pay almost all their wages to fill up their tanks or they do not move. Both choices are detrimental and with the first choice comes complete deprivation of all other needs to survive the month.

The third major source of pollution is the Power Plant Emissions. One example is the electrical power plant in Zouk Mikael, which was built in 1956, and was first operated in 1983. The plant is equipped with four turbines and four stacks running on Heavy Fuel Oil (HFO-6; density of 971 kg/$m^3$) continuously at an average of 2.5 units per day (Lebanon Electricity Board). Each operating unit burns 40 tons of HFO per hour to produce a calorific value of 42000 megajoules/ton (Weather Forecast and Pollution Investigation for Lebanon report, FEA, AUB, 2015). Reported emission amount to ~1800 Kg of total suspended particle per day from which expected are particulate matter (PM), particle bound Polycyclic Aromatic Hydrocarbons (PAHs), a type 1A PAH carcinogen; Benzo[a]pyrene (BaP),and Sulfur dioxide;($SO_2$ ) (Millman, Tang et al. 2008).

The continuous emissions of black fumes from the power plant stacks and the association of these fumes with increased hospital admission as well as reported 80 cancer cases/year alerted the ~350,000 residents living in the areas surrounding the Zouk Mikael plant. The repetitive requests from the municipality of Zouk Mikael to the government to replace the old turbines running on heavy fuel oil with new ones operating on gas or relocate the power plant did not lead to any concrete action. This negligence from the part of the government pushed hundreds of residents in the region to protest, between April and July, 2015, by blocking the main road that connects Beirut; the capital, with northern Lebanon.

Measurements of air pollutants in the area showed that the concentration of BaP in Zouk Mikael is at least 10 times higher than a city background site. This is mainly due to the fact the Zouk power plant is not well maintained and the fuel combustion process is not controlled. In fact, emissions from fuel oil combustion depend on (i) the grade and composition of the fuel (ash and sulfur content), (ii) the type and size of the boiler, (iii) the firing and loading practices used, (iv) the level of equipment maintenance and (v) the completeness of combustion. For instance, the level of excess air plays a major role in the PM emissions. In fact, there is an optimal excess air level that produces minimum particulate emissions; above and below this value, the emissions increase rapidly. Maintaining the combustion at this optimal level results in a reduction of PM emission up to 40%. Low levels of excess air increases the fraction of unburned fuel at the boiler exit, which reduces the efficiency. High levels of excess air increase the stack loss due to the increase of the flue gas flow-rate exiting the stack at high temperature, thus decreasing the efficiency.

Note that a reduction in the efficiency increases PM emissions significantly since more fuel needs to be burned to obtain the same electrical energy output. Furthermore the combustion temperature should be sufficiently low in order to reduce the flue gas thermal loss, but not too low to prevent oil atomization.

In Lebanon, the misuse extends beyond the air alone; it taints the very waters as well. Indeed, although Lebanon is a relatively water-rich country in the water-scarce MENA region, mismanagement, contamination, and run-off into the sea have compounded to create a grave water crisis. Last summer, UNICEF warned that 71% of Lebanon's population risked running out of water. The water that does exist is often unsafe, with 92% of wastewater in Lebanon disposed of without treatment. Over 96.2% of our river water harbors fecal coliforms and 95.5% harbors E. coli.

Wastewater management is considered one of the greatest challenges that Lebanon faces. Sewage effluent from communities, towns and cities throughout Lebanon are routinely discharged into waterways, the subsurface, and the Mediterranean Sea. In most cases, these effluents are not treated or controlled, and where treatment exists, it is rudimentary. Until this day, effluents from coastal areas are discharged into the sea while effluents from communities in the hinterlands are disposed in rivers, streams, on open land or underground, and the situation is exacerbated by the ongoing influx of Syrian refugees since 2011.

To date, despite receiving over 1.2 billion dollars in donations and grants dedicated to resolving Lebanon's wastewater problem over the past 10 years, many of the country's wastewater treatment plants are either non-functional or very few operating at limited capacity. Notably, in just one district alone, there are 11 wastewater treatment plants, none of which are functioning. Numerous municipalities resort to discharging untreated or partially treated wastewater directly into the sea or nearby rivers. This practice poses significant risks to various stakeholders. Farmers who rely on river or groundwater sources for irrigation face potential contamination from the polluted water. Swimmers enjoying coastal areas and refugees who depend on springs for drinking water are also at risk. Approximately 90 percent of farmers in Lebanon employ groundwater for irrigation. Although regulations exist for the use of treated wastewater, compliance is often lacking, and monitoring these practices proves challenging.

Lebanon hosts almost a 1.5 million Syrian refugees residing in informal tented settlements, or where affordable in local residential areas, causing an additional shock to the wastewater (and water) infrastructure. Many of the settlements release their wastewater directly (untreated) either into the neighboring watercourses and rivers, or into latrines connected to holding tanks that are de-sludged periodically. This ongoing humanitarian situation has increased water quality threats due to the temporary lack of sanitation measures.

There is also evidence that the refugees use surface water in their camps. At a national level, the extent of the water contamination is poorly understood in the near absence of monitoring on generated wastewater volumes, discharges, composition, and organic loading. Public awareness campaigns on mitigation and impact of wastewater pollution are hardly present and when they are, they are devoid of important numerical figures.

Moreover, our water, not only contaminated, has also transformed into a vector for the proliferation of diseases. In fact, due to a number of variables that foster the spread of cholera, a deadly bacterial infection caused by contaminated water or food, the disease is expanding rapidly in Lebanon. In fact, it spread quickly due to poor waste management, restricted access to clean water, and lax hygiene standards in Lebanon. Moreover, the issue is made worse by the fact that informal settlements and congested refugee camps in Lebanon frequently lack basic sanitary facilities and appropriate medical care. In addition, Lebanon is vulnerable to the disease being imported from nearby nations due to its geographic position and open borders.

Hence, it presents no surprise that Lebanon reported its first case of cholera since 1993 on October 6, 2022. As per UNICEF, the outbreak quickly spread across the 8 governorates of Lebanon and across 18 out of the 26 districts. As of January 17, 2023, 6,158 confirmed and suspected cholera cases have been reported in Lebanon. What is even more concerning is that due to the inadequate water standards in schools, children emerge as the most susceptible group to cholera outbreaks. Hence, approximately 45% of suspected and confirmed cases involve individuals under the age of 15.

In addition, Cholera outbreaks in Lebanon affect both women and men. However, because of their caregiving obligations, limited healthcare access caused by mobility, cultural, and financial barriers, as well as their particular demands, women are frequently more vulnerable than men to the outbreak. In fact, according to the WHO, 72% of the total cases are females – as per October 13, 2022. In June 2023, the Ministry of Health officially declared an end to the cholera outbreak. However, its lingering effects continue to be felt even now, and concerns regarding water and food quality in Lebanon persist. In a land where the bare minimum standards for air and water quality are shamelessly disregarded, can we realistically anticipate anything better when it comes to the dire state of solid waste and land degradation? Of course not.

In fact, Lebanon's waste problem continues to affect the natural world and human lives. Collection is unreliable and the government barely provides funds or technical support for municipalities. Open dumping and burning are rampant and often the only option, amounting to an estimated 900 open dumps in the country.

The solid waste sector produced 11% of the country's greenhouse gas emissions in 2011. In 2018, Lebanon lost $200 million due to the lack of solid waste management.

The mountains and hills that still have functioning ecosystems are consistently targeted. Due to corruption and spotty land records, unregulated development overtakes pristine areas, and faulty construction deals abound. For example in 2020 the World Bank infamously canceled its loan for a dam in Bisri, after local activism showed that construction would destroy a highly biodiverse ecosystem, multi-cultural historic sites, agricultural areas, and bird migratory areas.

As for our lands and biodiversity, the energy and economic crises in Lebanon have forced many locals to take unlawful actions, like felling their own trees. Indeed, people are desperately looking for new sources of energy and revenue because of the severe electricity shortages and the skyrocketing cost of fuel. Unfortunately, this has resulted in a pervasive practice of unlawfully cutting trees for fuel or to sell as lumber. As a result, thousands of oak, pine, fir, and juniper trees, some of which were centuries old, were illegally cut down. The ministry of Agriculture sent many exhortations to halt this practice. However, just like most decisions made by our government, they often lack follow-up, commitment, dedication, and genuine care. Hence, the following question arises: in a country where the only law is the absence of law, how can we condemn individuals who, driven by desperation, grasp at their final opportunity to keep warm amidst the unforgiving winter? Trapped in the murky space between innocence and guilt, one undeniable truth remains: it is the people who endure the brunt of the suffering, along with our invaluable trees.

Despite all those environmental challenges and hurdles, many are trying their hardest to help, from NGOs, to foreign actors, to citizens. However, structural problems have consistently undercut all efforts for change. Foreign aid is crippled by corruption and inefficiencies -over the past 30 years Lebanon has received billions of dollars in aid and yet running water and electricity are increasingly sparse. The nonprofit sector has attempted to take on the difficult task of filling in for the social state. However, the absence of robust public institutions capable of ensuring project sustainability renders these efforts incomplete and puts at risk, more often than not, the considerable funds invested in them.

The ongoing devastation in Lebanon, compounded by its location in a climate change hotspot, poses a significant threat to an already fragile system. In many ways, this situation is more perilous than the localized impact of the Civil War. It represents a comprehensive conflict that undermines the fundamental aspects of life, affecting the air we breathe, the water we rely on, and causing soil erosion through deforestation, thereby endangering our food supply.

The rampant environmental degradation in Lebanon is accelerating the total collapse not just of ecosystems but also of the country, its identity, and its cultural heritage. Coupled with socio-political shocks and exacerbated by the climate crisis, this degradation threatens our future. In the most unwanted ways, Lebanon is consistently demonstrating that the environment is interconnected with socio-economic stability, and is not something to be cast aside as a nature lover's fancy.