1952's the Great Smog, Exploring the Past with Simulations.

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Abstract

Systems dynamics allows us to address complex issues in order to understand the behaviors that occur through the interaction of the structure. This document allows us to delve into a historical fact seen from the perspective of fiction. We are going to address the complex event of 1952, called the great haze, which occurred in London in the month of December 1952.

We will face this event from fiction seeking to obtain a generic structure in order to calibrate it in the next steps, but from today, it will give us light on the effects of the policies that are carried out in similar systems.

The structure determines the behavior of the system and it is this premise with which we will approach this problem, without resorting to data, only with the inspiration of a TV Show (The Crown).

Outline

- 1952’s the great smog
- Introduction
- System Description
- Dynamical Hypothesis
- The Structure Behind the Behavior
- Conclusions
- Next Steps

Image 1: Policeman wearing mask in a London Street
Source: google.com

1952’s the great smog

It was a cold winter in London, everything seemed normal. 8 million Londoners lit their chimneys to mitigate the cold. But in one of those buildings something else was happening, a somewhat different reading suggested an unprecedented event, in which, like a mentor to current film scripts, an unknown scientist was kept silent, and with him, the clues that they were able to prevent the following events.

In many stories, a dynamic situation unfolds over a period of time, in this story, it takes less than a week. The clash of two phenomena condemned the lives of 16 thousand Londoners, 2 for every 1,000 in the six months that followed, that is the same death rate of Covid in some countries, 1/4 of those happened in the first 4 days.

1952's the great smog

The present case makes us wonder what lessons we can draw from this historical fact. First because of the accidents that cause it, then because of the structure and what it implied at the time.

After World War II, Great Britain, decided to overcome the war and get out of its precarious economic situation. One of the decisions they made was to sell their high-quality coal, keeping low-density coal and a high sulfuric acid content for local consumption.

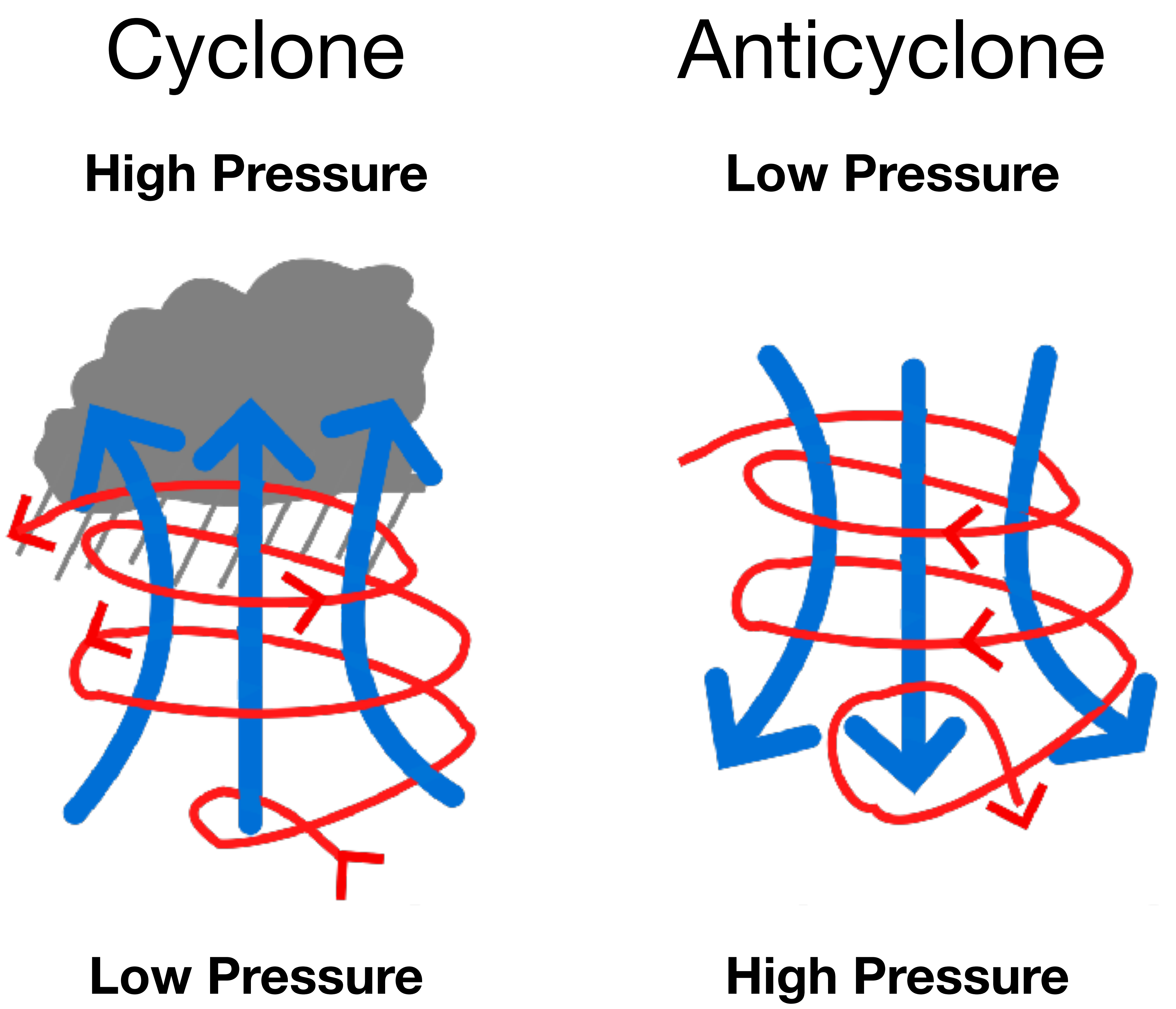


Image 2: Example of Cyclone and Anticyclone.
Source: google.com

1952's the great smog

At the beginning of winter, a cold front approached, which collided with a high pressure system, coupled with this, the temperature differential caused by the burning of coal in factories and homes, as well as fossil fuels burned in vehicles, gave rise to an anticyclone, a meteorological phenomenon that causes a high pressure system to remain on the surface, making it impossible for gases to escape and their degradation in the air.

Meanwhile, little could be done, it would last as long as God decides. Business continued with a Business as Usual policy, no one raised a finger when hospitals and the transportation system collapsed, thus increasing deaths and the duration of the event.

What can we learn from this experience? How can we learn from the past using simulators?

Image 3: Visibility on streets.
Source: google.com

Introduction

In an unprecedented event, there are very few things that can be done, especially when the computing power and sensors that we have today, even with satellites, did not exist, to understand the weather effects that surrounded any part of the world 70 ago. years must have been technically impossible. And the understanding of the community about the issue close to null.

At the same time, since there is a record of this event, and the effects it had on the formulation of legislation to improve the environment, it is a story worthy of better understanding.

The objectives of this work will be to establish a stock and flows model that can reproduce the behaviors that are glimpsed in this story, of which we know little data. Then, we will draw some scenarios that allow us to answer what would happen if alternate paths had been taken. Finally, we will look for new policies that allow us to understand if the event could have been prevented or only attenuated.

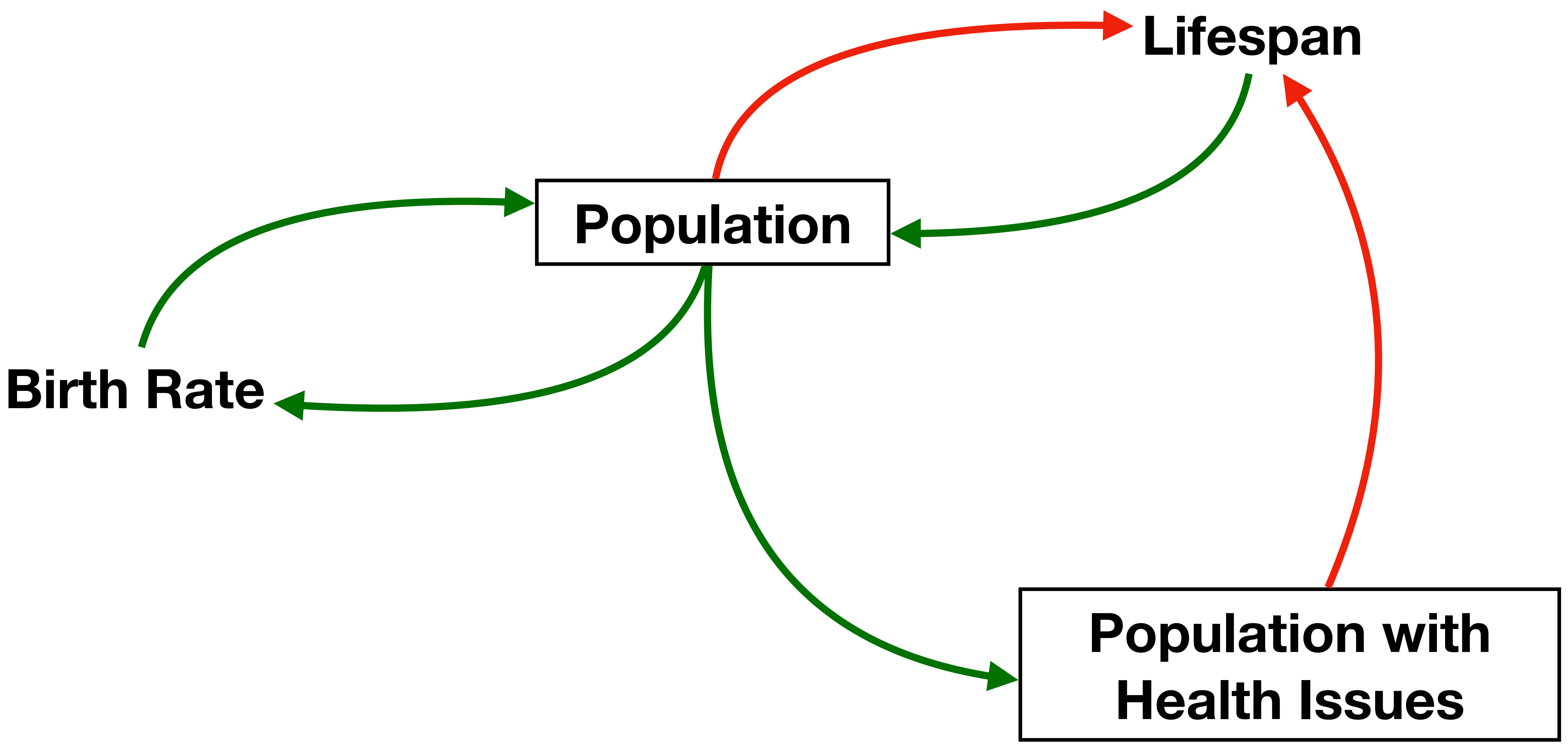
We will seek to conclude with clues that allow us to apply this model in a generic way to problems of our times, as a proposal for discuss the effects of its application.

System Description

We will start the description of this system with the obvious parts. It is a city where a population lives, this population has dynamics that make it decrease and increase over time. The more population we have, the higher the birth rate, which increases the population, forming a reinforcement feedback loop. This population has a life expectancy, the greater the life expectancy, the fewer people die.

We can deduce that of this population there is a fraction that can be found with a health issue, the more people with health issues, the average life expectancy of the population decreases, causing more deaths. We must assume that the more population we have, the number of people with diseases will increase. This structure is part of the "Population" sector.

System Description: Population Sector



Indicates direction and a Positive or Supportive Relationship
Indicates direction and a Negative or Opposite Relationship

Image 4: Population Sector CLD.
Source: own elaboration

System Description

When winter arrives and temperatures drop, the population seeks to maintain a warm environment inside their homes, the colder it gets, the need to keep the fireplace burning increases. The more chimneys lit, the more carbon consumed, and the more carbon consumed, more smog is generated. Now, the quality of the coal involves two factors, the first is that the higher the quality, the higher the density of the coal, therefore less quantity is required to heat for a longer time, and second, the higher the quality the toxicity of the resulting smog is lower.

Something similar happens with factories, which at that time operated with coal.

And we add to this sector cars and public transportation service, which consume a quantity of fossil fuels and generate a quantity of smog with a specific toxicity. These elements are part of the smog generator sector.

System Description: Smog Generators Sector

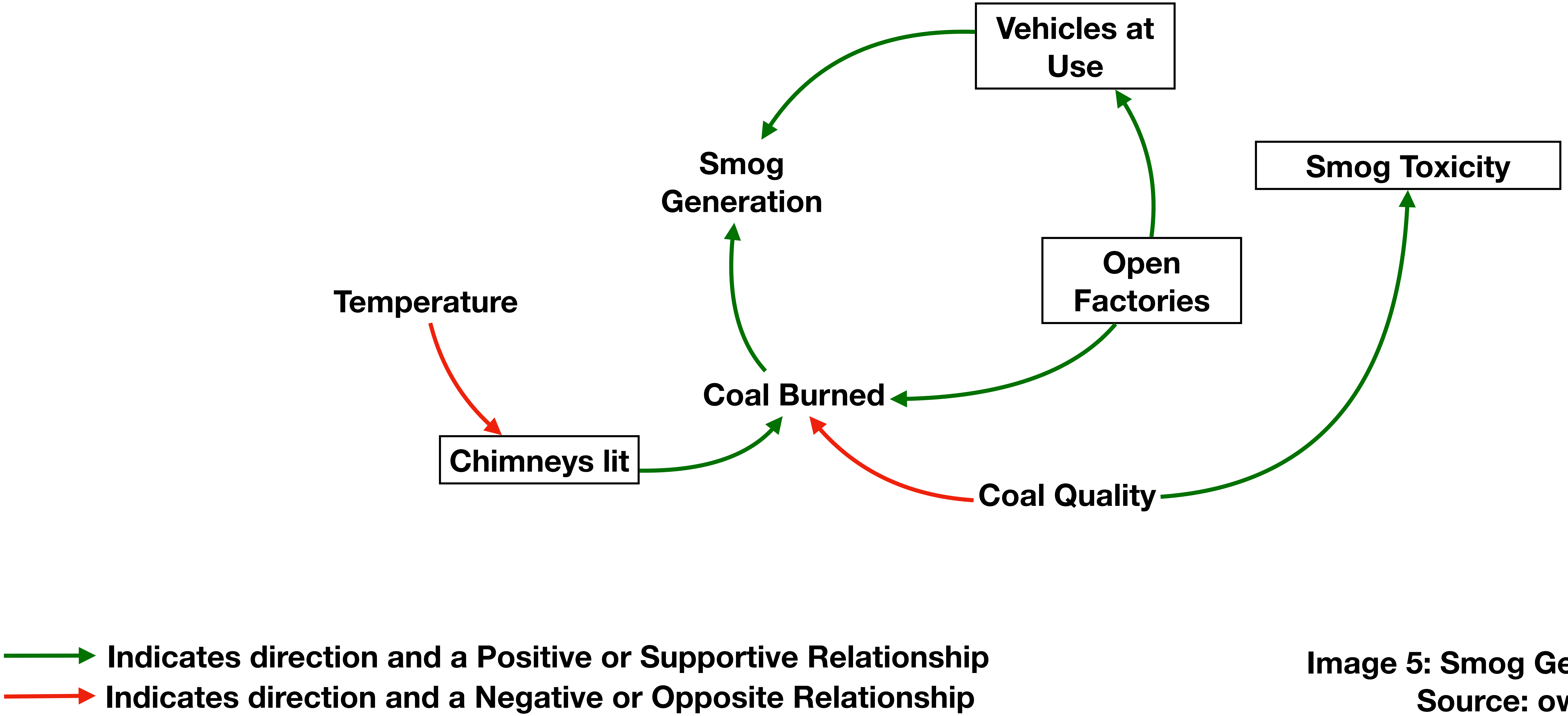


Image 5: Smog Generators Sector CLD.
Source: own elaboration

System Description

Now let's think that the more smog generated, there is a greater amount of smog in the environment; Let's assume that smog in the environment has an absorption rate, and the higher the absorption rate the amount of smog in the environment decreases. The greater the amount of smog in the environment, the visibility on the roads decreases.

And since we are considering that all this was aggravated by the presence of an anticyclone, then, the greater the pressure generated by the phenomenon, the lower the rate of absorption or dissipation of the smog, a situation that makes the smog last longer contained in the area. geographic.

Finally, we consider that there is a cold front that makes people light their chimneys, artificially increasing the temperature, by contrasting the temperature of the cold front and the artificial one, we have a temperature differential that increases the effect of the anticyclone. These elements are part of the structure of the sector called the environment.

System Description: Environment Sector

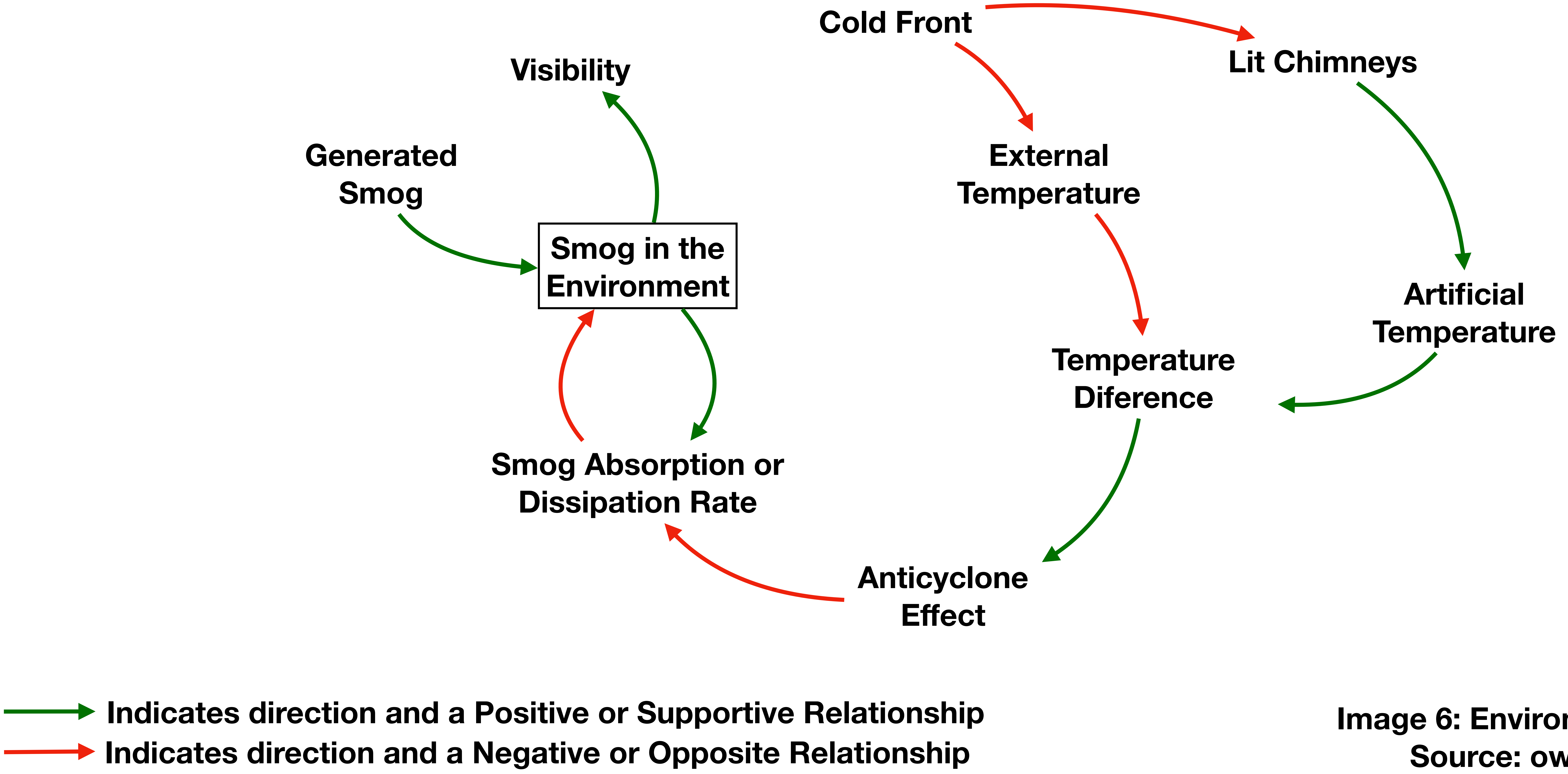


Image 6: Environment Sector CLD.
Source: own elaboration

System Description

The last sector of this model is public health, in this sector a standard capacity is established for the given population, this capacity depends on three key elements: the health staff, the infrastructure (buildings, rooms, beds, machines, etc. reduces to a capacity of people cared for) and finally health supplies (medicines, healing materials, syringes, etc.).

The balance of these three elements allows for a standard of service, but the fall in any of these three ignites stress behaviors that make the medical staff stay more or less time. These stress effects are described later.

In this sector, the balance of the health system is contrasted with the need for admissions, this need for admissions grows when the number of people with health problems increases.

System Description: Healthcare Sector

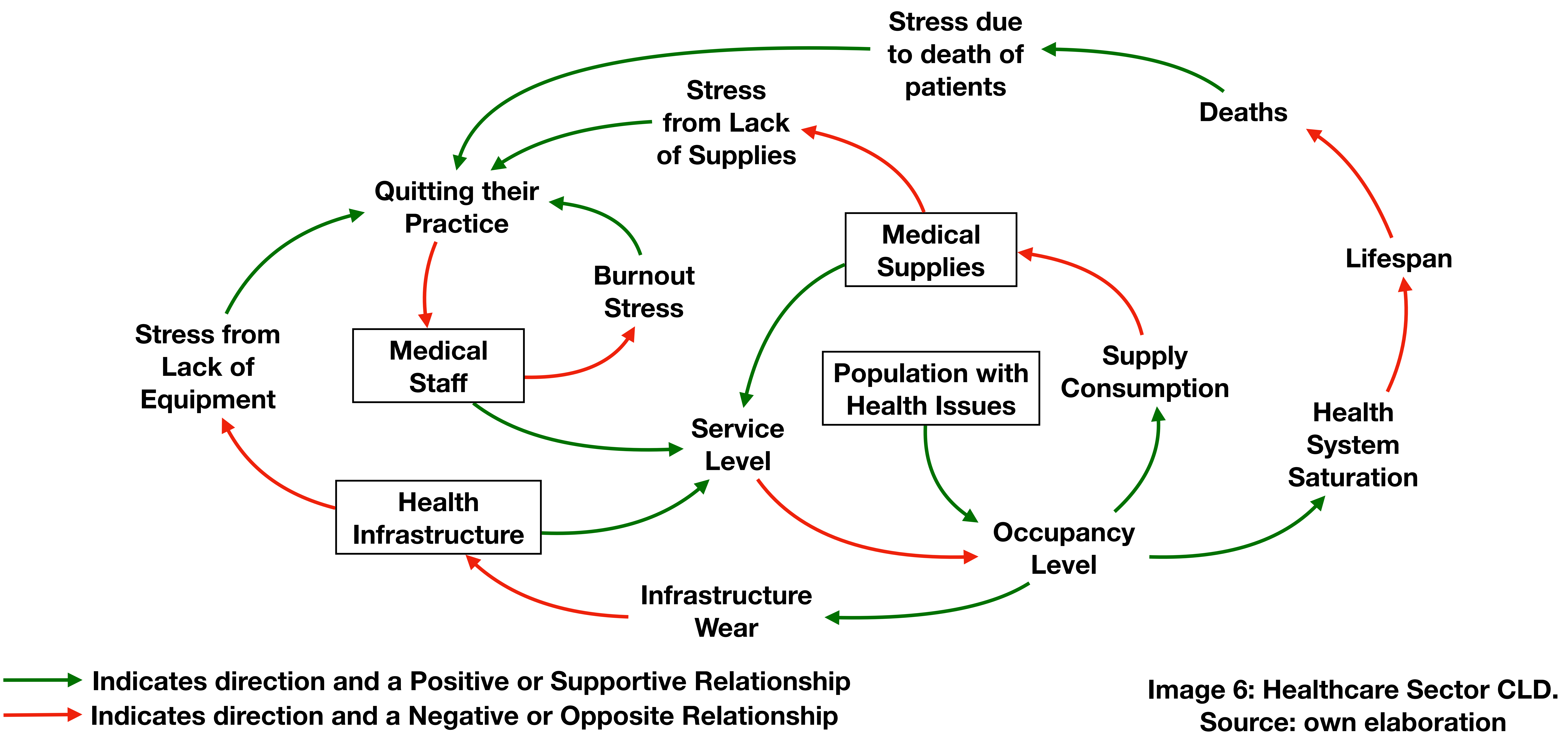


Image 6: Healthcare Sector CLD.
Source: own elaboration

System Description

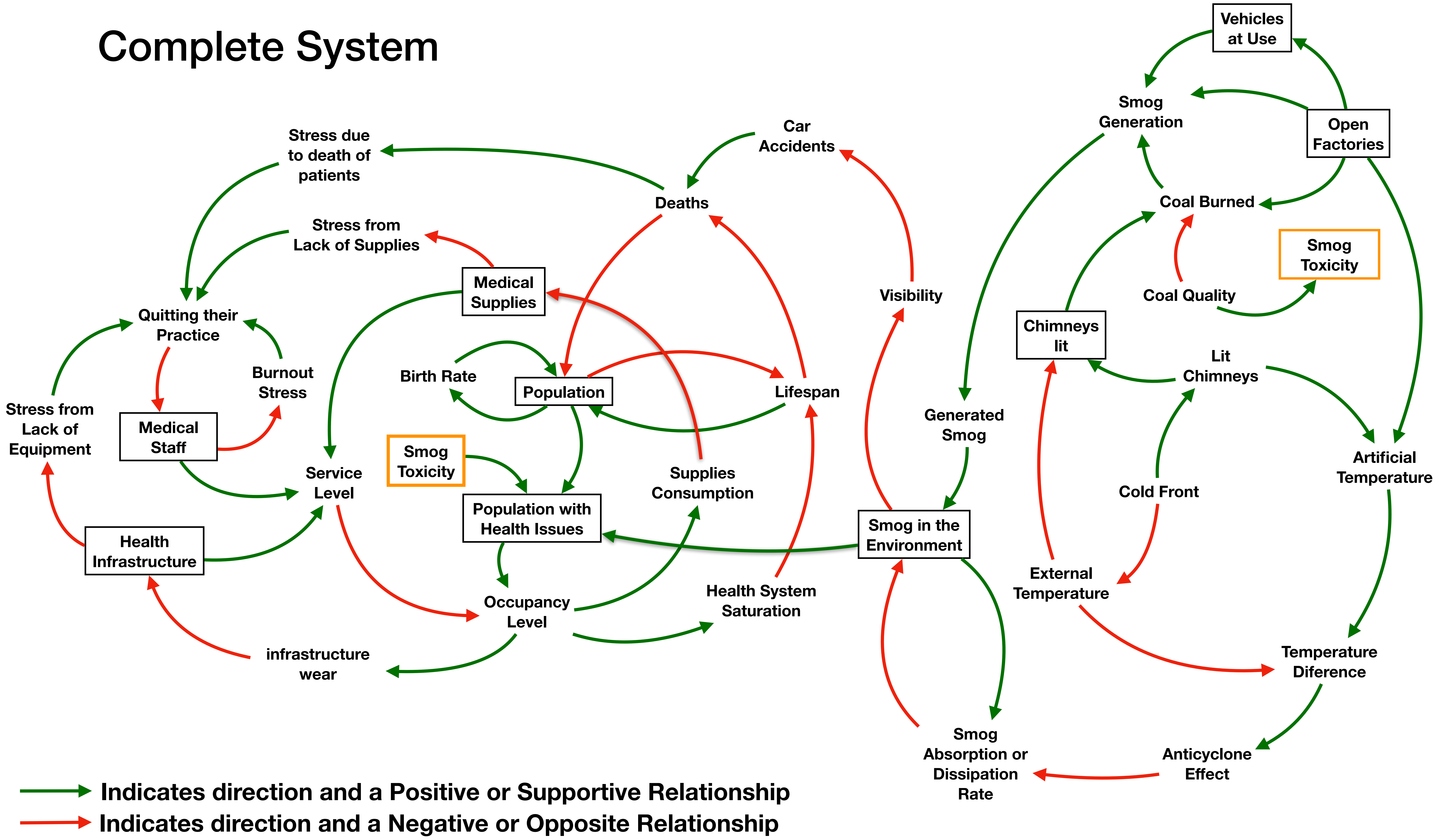
Stress due to lack of equipment, occurs when the level of occupancy is higher than normal, in this case the wear and tear of the infrastructure increases, causing a decrease in the medical infrastructure, which leads to increased stress due to lack of equipment. This effect increases the amount of staff that renounces their practice.

Burnout stress, as there are more medical personnel who quit their practice, the stock of medical personnel decreases, forming a reinforcement cycle that causes more personnel to leave their jobs.

Stress due to the death of patients, as the level of occupation increases, the health system is saturated, this decreases the life expectancy of the population, which increases deaths, the medical personnel when perceiving this, increases their stress due to loss of a patient that can lead him to give up his practice.

Stress due to lack of medical supplies, supplies depend on a budget and are planned for a specific capacity, by saturating the health system, medical supplies decrease rapidly as they are not supplied at the same speed at which they are used, this leads to The medical personnel do not have the material they require, causing stress due to lack of supplies, this in turn increases the resignation of medical personnel to their practice.

Complete System



The Structure Behind the Behavior

Following the causal loop diagrams shown in the system's description as a basis, we developed the structures of the sectors that make up this model. Specifically, the model is made up of 5 sectors that are: population, health system, smog generators, environment and policies. To have a starting point, it is desirable that the model can represent a baseline in equilibrium.

We will discuss an overview of each sector in the following slides.

Population Sector

In this sector the important thing is to understand the relationship between the population and people with a disease. We are assuming that of a given population there is a normal fraction that may have health problems, most likely this number depends on the lifestyle, culture and economy of the country because it is a fiction-based system, we will consider that 5% of the population may have a disease at some point in time due to various allergic, viral, psychological, physiological situations, etc.

Healthcare Sector

We are going to assume that in general, a health system would be designed to serve the normal number of sick people (5%) plus an additional percentage (50%) of sick people over time, both parameterized in the simulator. For this to be possible, the health budget would be based on this assumption and would not normally have much slack, and we assume a standard budget of 50 Pounds per patient per day.

As we explain in the causal diagram in the public health system, what we see is the relationship between the 3 most important resources for public health that are medical supplies, infrastructure and medical personnel, These 3 resources are in a normal position, they are only seen affected when there is a catastrophic situation affecting the health index, the balance of these 3 factors depends on normal values of a normal budget availability to cover this need, here what we are saying is that if the city delivers the resources considering inflation normal, the 3 resources will remain in balance.

Healthcare Sector

The health index controls the capacity structure of the health system, this is a dimensionless factor between 0 and 2 that follows a distribution in the form of "s" when it is 1 it remains in equilibrium and when it rises from 1 it means that the system The health system is saturated or there is hospital overcrowding, when the value is less than 1, the health system would be underutilized, a situation that is good up to a point.

Smog Generators Sector

This sector is designed to see the relationship of the resources that generate smog. So the vehicles are smog generators because they consume fossil fuels but the details of this are not shown since the important thing is to understand the behavior of coal consumption over time. Now the smokestacks and factories consume a normal amount of coal, but when the coal is of low density more coal is required to do the same activity. Recall that in the graph of coal consumption, the low density of coal makes me consume more coal, the more coal I consume, the more smog I generate. In this sector we are only going to consider a normalized index where we compare consumption in the initial time against consumption at the present time and this will be connected with the environmental sector through a dimensionless effect.

Environment Sector

The environment sector considers the accumulation of Smog in the environment, this in turn has a density that is given by the amount of smog and the area it covers. As this increases, it gives way to the visibility index that connects with the population sector and with the generators sector.

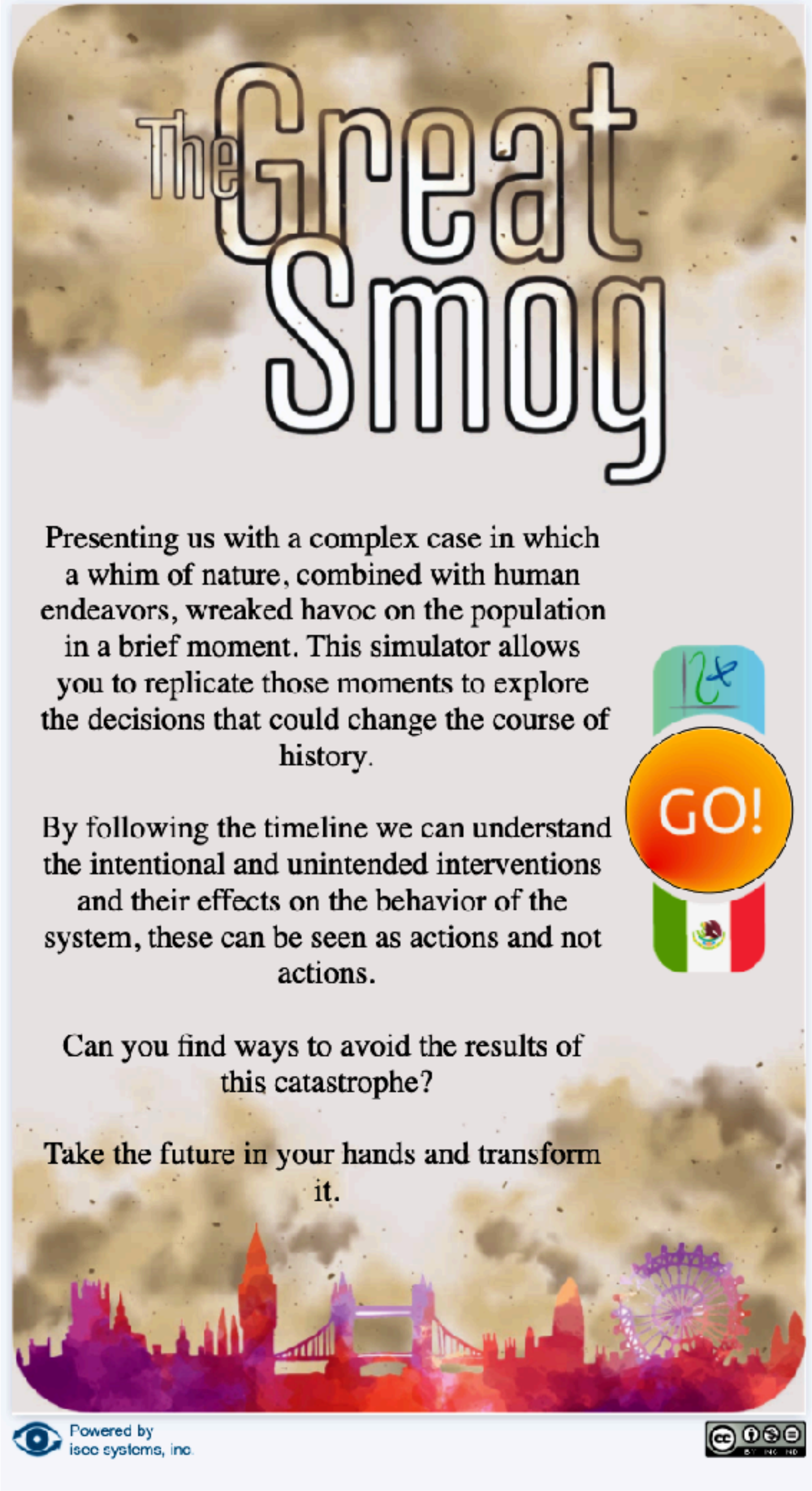
Smog increases its toxicity index as the quality of the carbon decreases and at the same time as the density of smog in the area increases.Finally, an instrument is described to understand the relationship between the climatological temperature and the artificial temperature caused by man, and how its temperature differential creates the high pressure system that causes the absorption rate of smog to decrease.

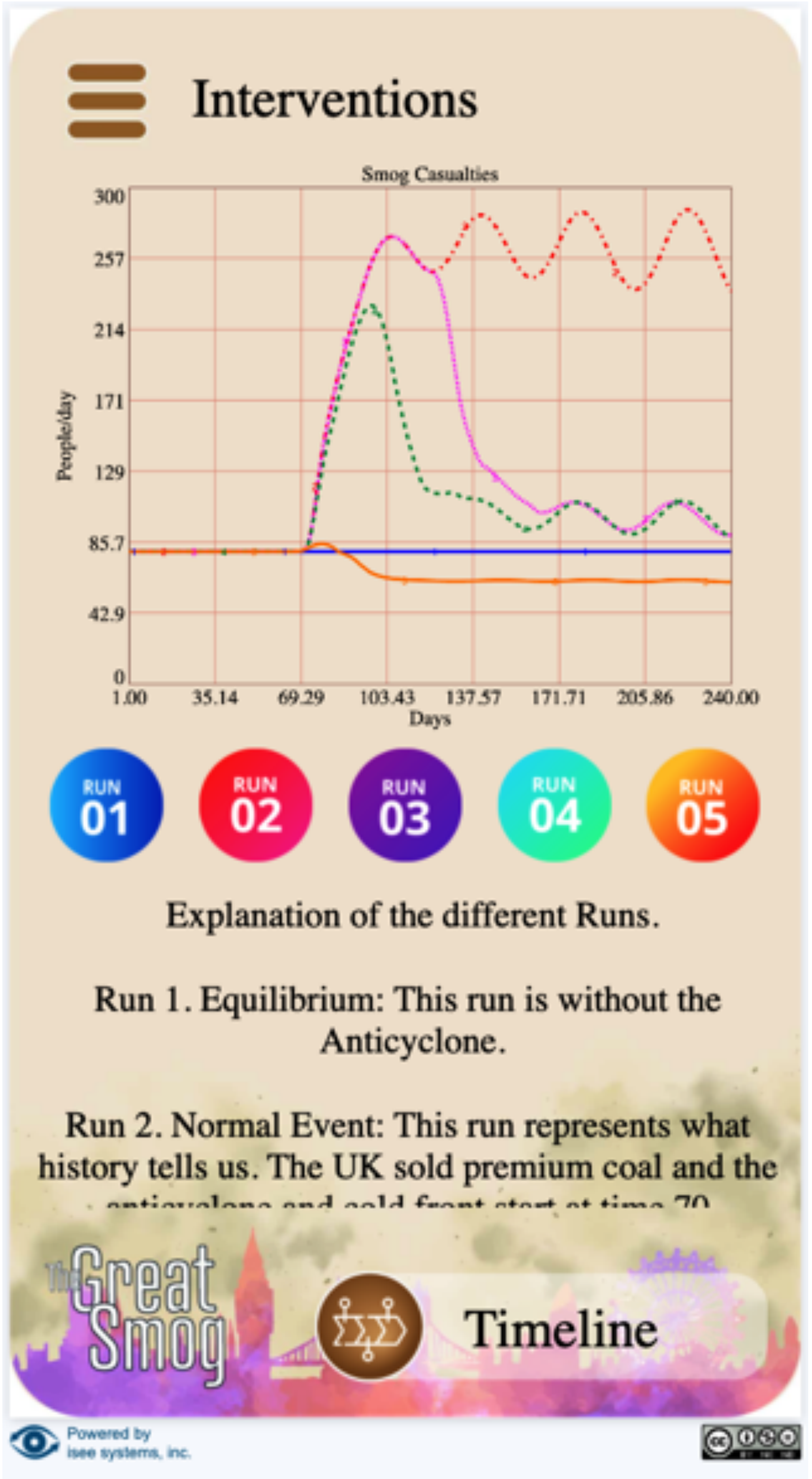
Policy Sector

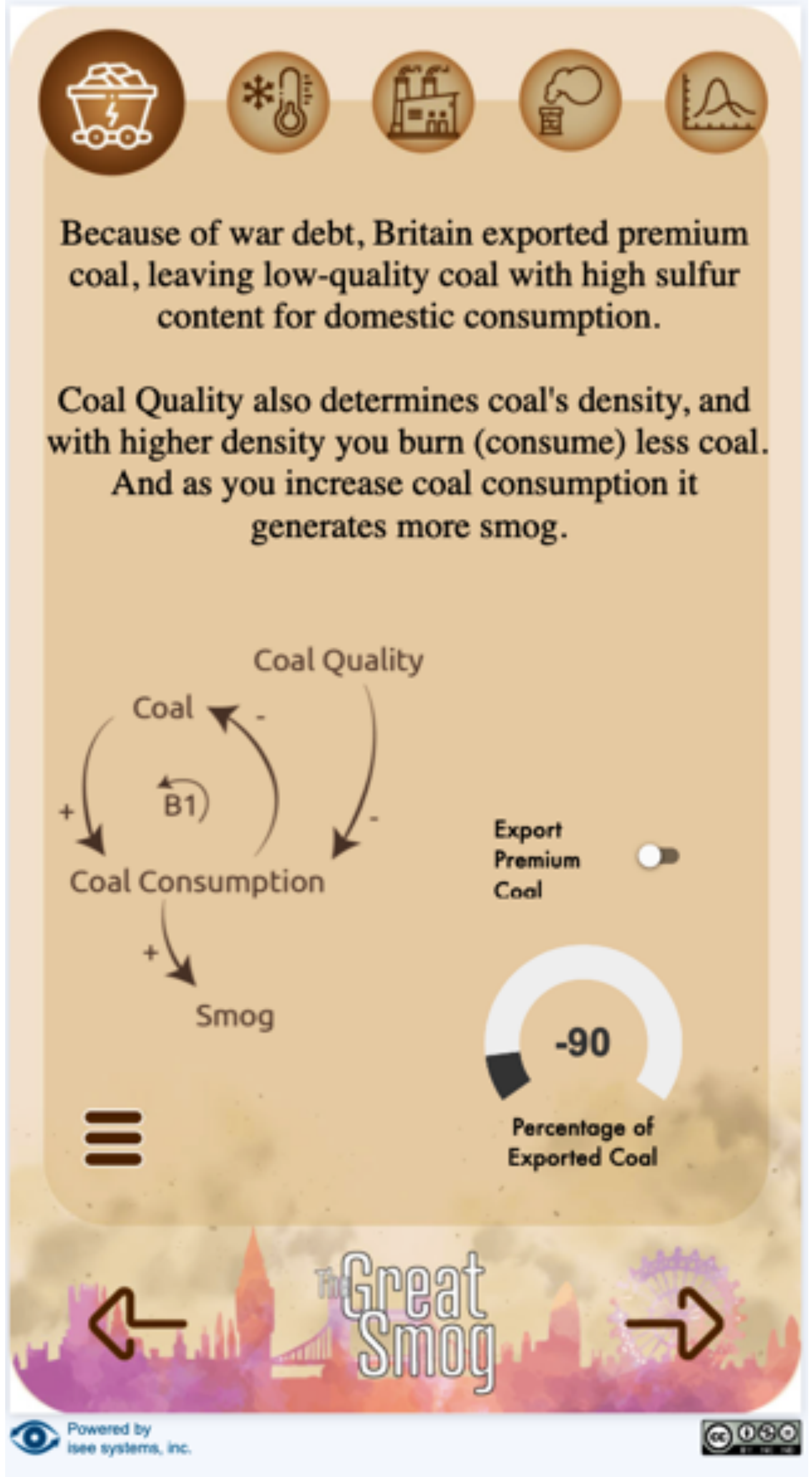
The policy sector is implemented with the purpose of executing a systematic analysis that allows us to understand how the interventions carried out affect the complex system. Implementing it this way hinders some of the benefits of having Loops that Matter or conducting Sensitivity Analysis, but there are a few ways to accomplish them.

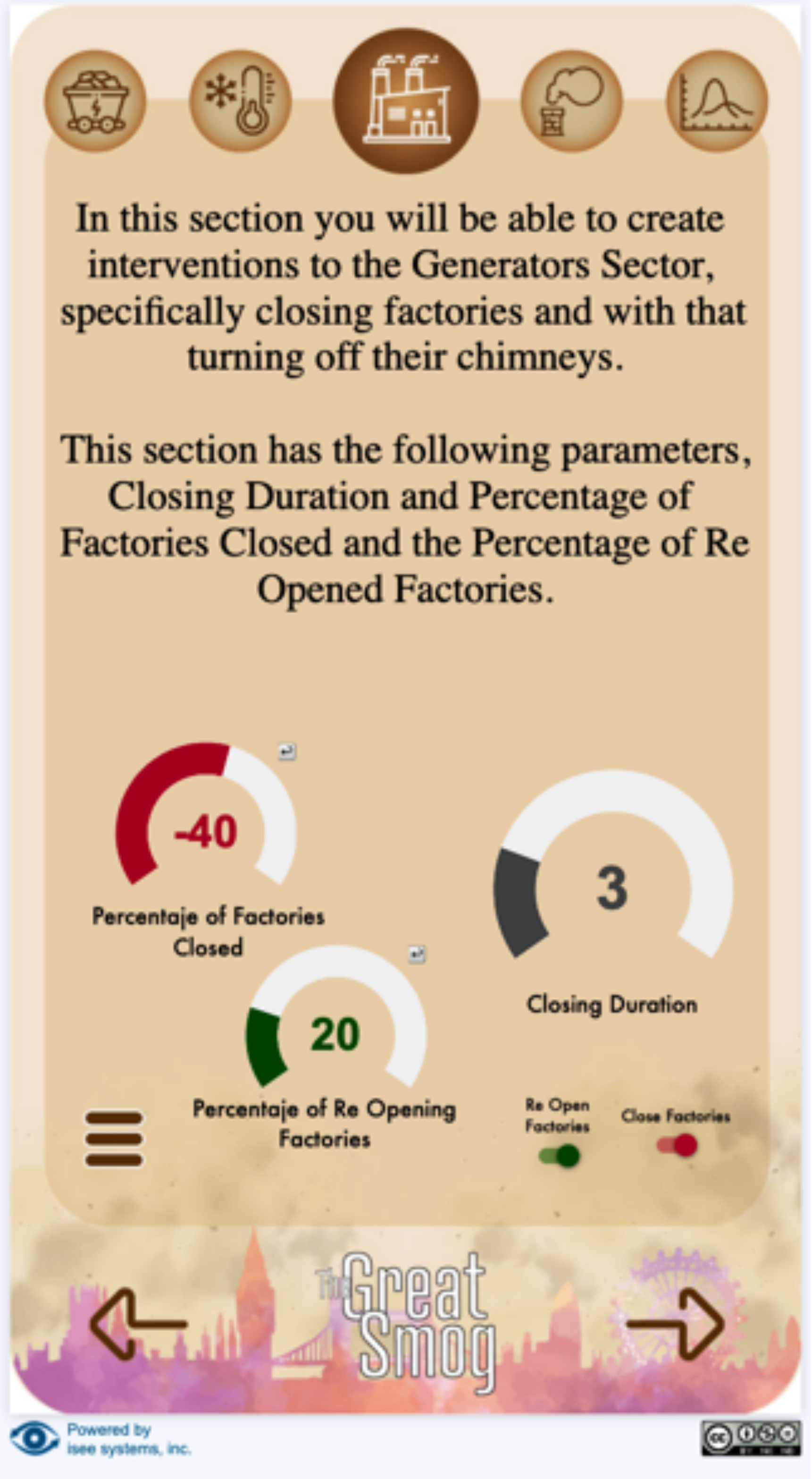
This simulator has some variables that are not necessary for the model to work, but are important as a logic layer to present the model in the form of a learning lab.

Interface Link









Conclusions

In the graphs of this simulator we can find that we have achieved that the model presents a stable state for the standard conditions that we have proposed. Likewise, we can see that the main dynamics are possible by activating the policies that we have designed to understand more about this model.

It is important to understand that we have to calibrate and find more information that allows us to present deeper insights for this system, however, each step is incremental and allows us to have a more useful model every time.

Next Steps

This exploratory study has several behaviors that can replicate current situations in different countries. It could reproduce air pollution systems and could help in the design of policies and its proper implementation.

There is more validation needed this model, as new loops arise, the need of more Sensitivity Analysis is needed. Still the goal was met as it reproduces the behaviors described.

As George Box wrote “all models are wrong, but some are useful” our intentions are to build a useful model, and that can only be achieved as stakeholders use the model and general public interact with it to leverage understanding of this complex system. In order to make it useful, when ISDC arrives, we are publishing a Learning Laboratory, designed with Stella Architect, and published at iSee Exchange, so that explorations within a set of boundaries is possible for others System Dynamicist and Stakeholders.

There is the need to discuss with air quality, pollution, healthcare and environmental experts, in order to validate the assumptions made in the system.

We are open for dialog.

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