1816, A Year Without Summer.

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Abstract

This study delves into the repercussions of the 1816 event, "A Year Without Summer," caused by the eruption of Mount Tambora. The volcanic activity led to a significant reduction in sunlight, resulting in global consequences affecting agriculture, human survival, and societal structures. Utilizing a system dynamics model, the paper explores the dynamics of this historical event and its potential implications if a similar occurrence were to transpire today. The study presents a virtual experience to be discussed at the conference, aiming to shed light on the interconnectedness of environmental events and societal responses.

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Introduction

The effects of climate change are causing more and more havoc in the daily lives of the world's population. Every day we see headlines where drought, landslides, wildfires, extreme climates and the loss of biodiversity are changing and reinforcing these effects.

That is why we have turned to the past to find stories that allow us to understand the effects of natural disasters on the world, its population, wildlife, politics, economics and environment, as well as the resilience to overcome such events.

Among these stories we find a peculiar one, which happened in 1816, known as "the year without a summer." It is a story that has it all, an erupting volcano, darkness, crime, famine, disease, a monster assembled from the pieces of human bodies, icy climates, and at the end of one year, a humanity that is reborn to arrive stronger the next millennium.

Problem Statement

In this story the problem presented is the effect of the reduction of sunlight reaching the earth, and all living beings. With this reduction, natural resources are decimated, having a great impact on the human, animal and plant population, as well as on social structures (infrastructure, social fabric, economy, culture and geopolitics).

This document describes the mental model behind this story. With this mental model we have developed a dynamic hypothesis in the form of a CLD that allows us to describe the connections of the system. With this diagram we have created a stock and flow model which is briefly described, and we have calibrated it to the reference modes that we infer from history. With this model we can explore living history and design scenarios to better understand the event.

Methodological Approach

Due to the lack of available data, we have decided to create a model that describes the structure of the mental model of said event and its effects, it is also a completely endogenous model containing no external time series to drive its behavior.

This CLD (Image 1: CLD of 1916 the Year Without Summer.) allows us to see the different causal cycles that are activated when the phenomenon that limits the entry of sunlight to the Earth begins. Attachment 1: 1816 A Year Without Summer CLD in Stella Architect.

From this dynamic hypothesis, reference modes were created as auxiliaries for modeling stocks and flows.

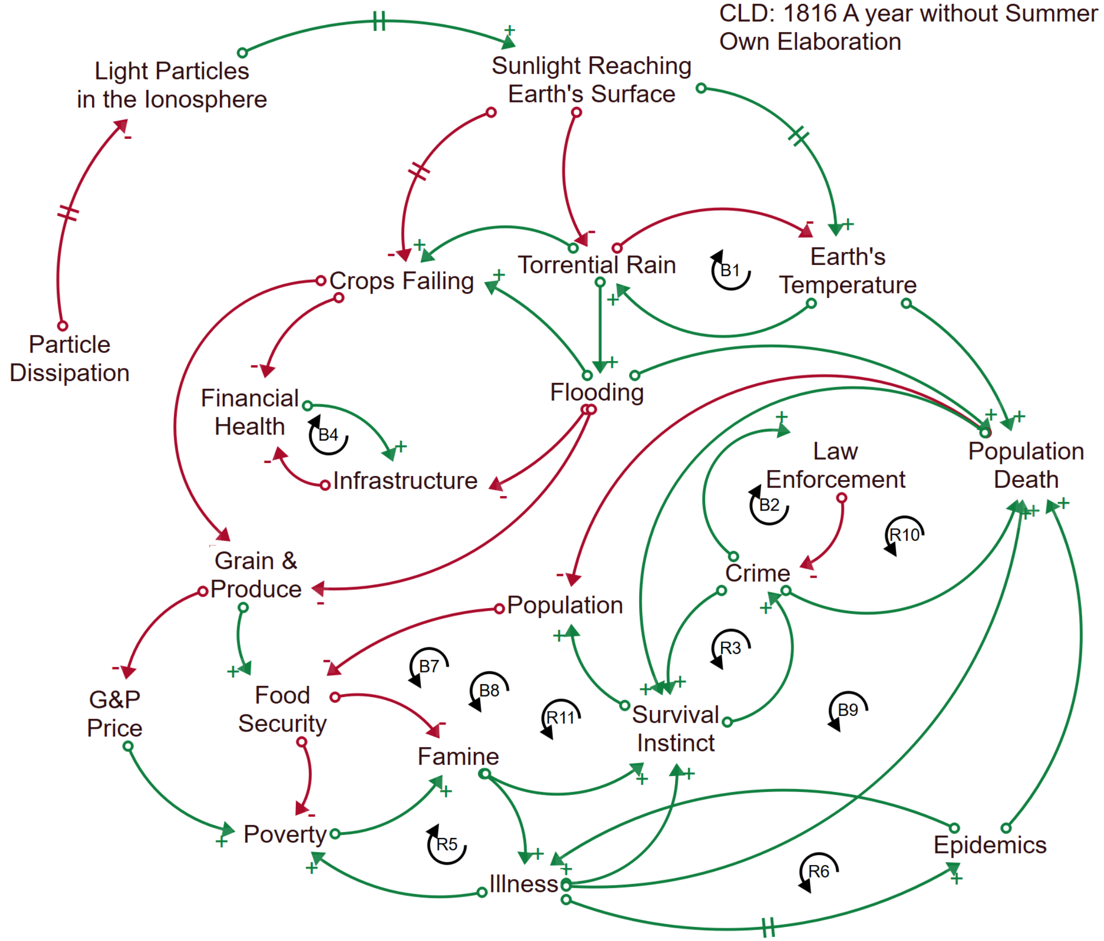


Image 1: CLD of 1916 the Year Without Summer

Methodological Approach

The model in general consists of a special structure for the accumulation of particles in the stratosphere, an inflow only with a pulse function and an outflow that forms a balancing cycle, since we assume that there are always particles in the stratosphere. light of different types. See Image 2: Particles in the Ionosphere Stock and Flow Structure.

This structure is connected to others that are interconnected with the others. In general we have 8 sectors that describe the environment (particles, sunlight, torrential rains and the temperature of the earth), infrastructure, services (crime, health and law enforcement), life (human and its survival instinct, and wildlife), agriculture (its crops and fruits and grains), health (of the population and epidemics), System Performance (Economic Health and Poverty Index), and finally Policies

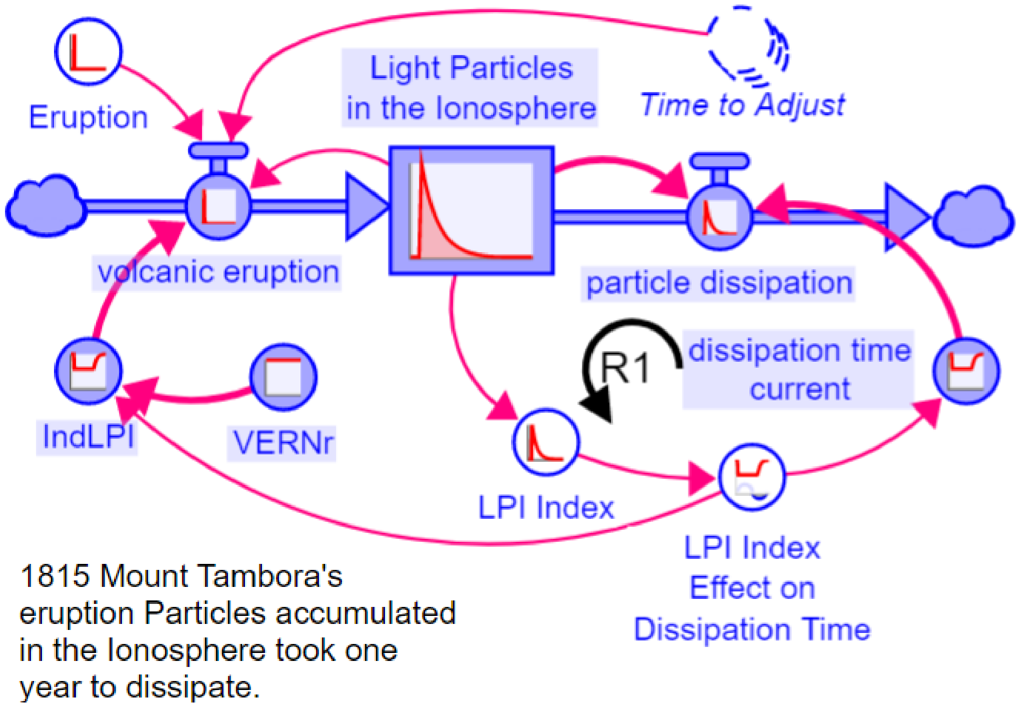
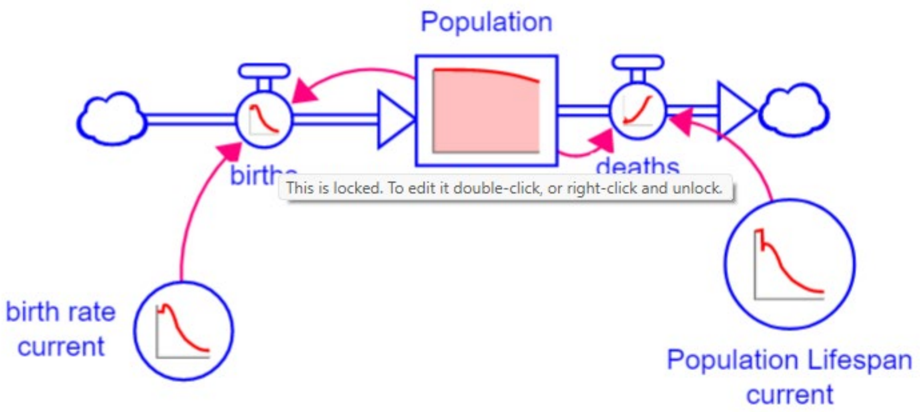


Image 2: Particles in the stratosphere Stock and Flow Structure.

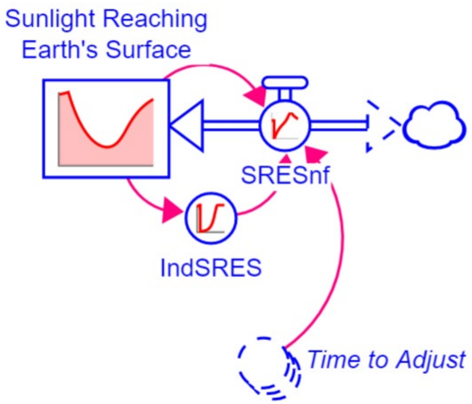
Methodological Approach

Their structures are basically of two types: 1) limits to growth structure, 2) goal seeking structure. That when interconnected form the basic dynamics of the mental model. Examples in image 4: LTG and GS structures. The model is generic, in the way that it can represent events of the past, the present and future. We can model future events and their consequences.

Limits to Growth Structure



Goal-Seeking Structure



Results

We present the behavior of the phenomenon produced by the volcano, which is essential for the following approaches. This behavior results in an eruption of such magnitude that a cloud the size of Australia is formed. That is like a pulse where light particles increase in the ionosphere, it is the only inflow, and they subsequently dissipate over the course of a year, the time it took for the event to end. Image 5: BOTG of Light Particles in the Ionosphere.

Then we present the behavior of the Population, Crime, Poverty and Epidemic stocks and their respective reference modes. Image 6: Stock BOTGs.

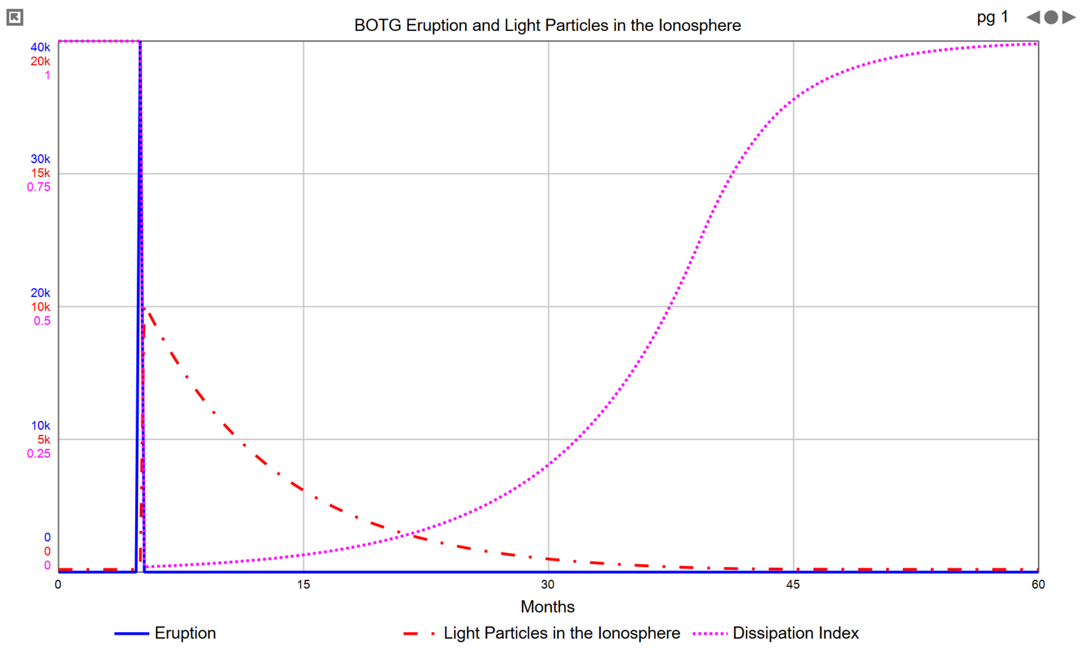
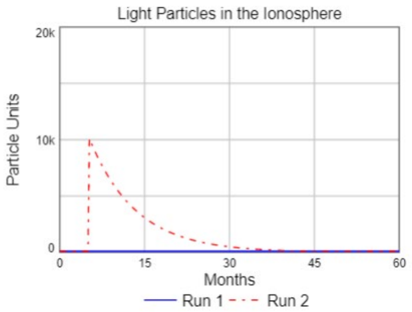
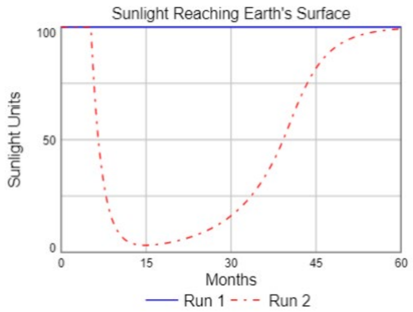
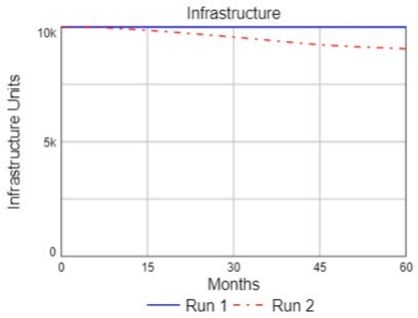


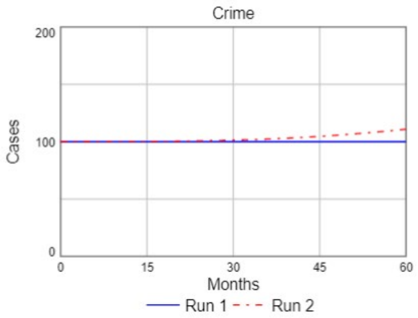
Image 4: BOTG of Light Particles in the Ionosphere.

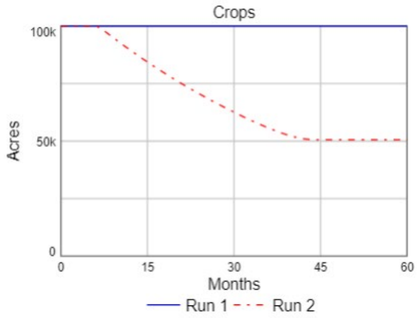
Results

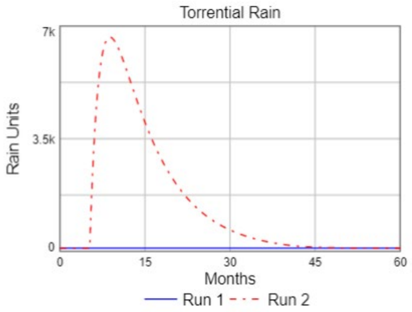

Light Particles in the Ionosphere
Particle Units
20k
10k
0
0 15 30 45 60
Months
Run 1
Run 2

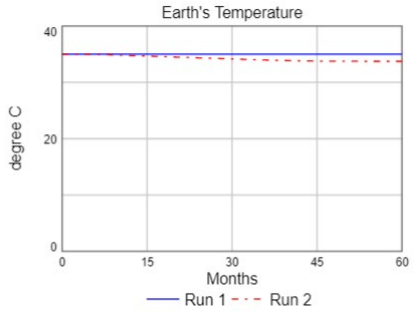

Sunlight Reaching Earth's Surface
Sunlight Units
100
50
0
0 15 30 45 60
Months
Run 1
Run 2

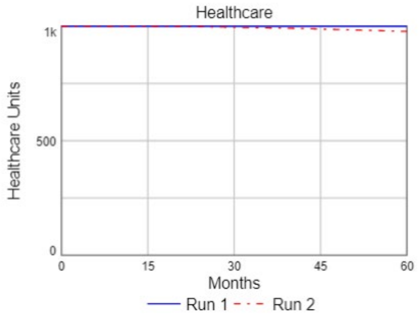

Infrastructure
Infrastructure Units
10k
5k
0
0 15 30 45 60
Months
Run 1
Run 2

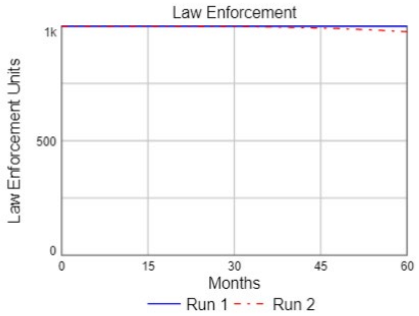

Crime
Cases
200
100
0
0 15 30 45 60
Months
Run 1
Run 2

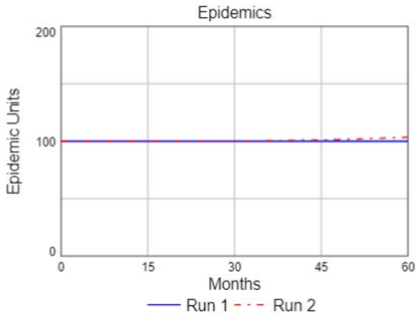

Crops
Acres
100k
50k
0
0 15 30 45 60
Months
Run 1
Run 2

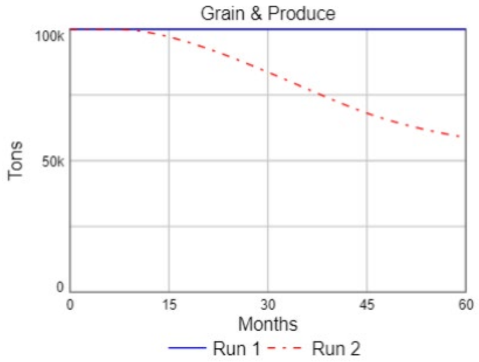

Torrential Rain
Rain Units
7k
3.5k
0
0 15 30 45 60
Months
Run 1
Run 2

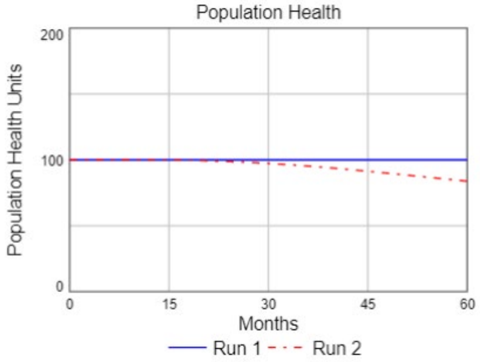

Earth's Temperature
degree C
40
20
0
0 15 30 45 60
Months
Run 1
Run 2

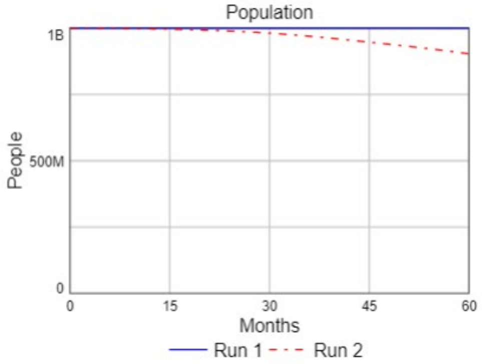

Healthcare
Healthcare Units
1k
500
0
0 15 30 45 60
Months
Run 1
Run 2

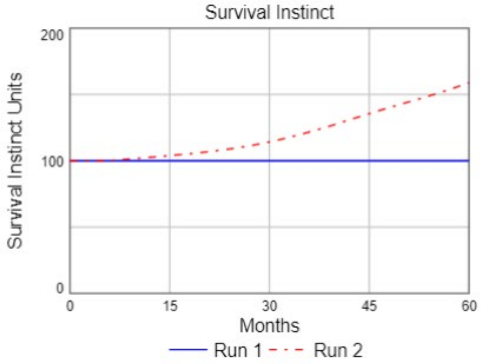

Law Enforcement
Law Enforcement Units
1k
500
0
0 15 30 45 60
Months
Run 1
Run 2


Epidemics
Epidemic Units
200
100
0
0 15 30 45 60
Months
Run 1
Run 2


Grain & Produce
Tons
100k
50k
0
0 15 30 45 60
Months
Run 1
Run 2


Population Health
Population Health Units
200
100
0
0 15 30 45 60
Months
Run 1
Run 2


Population
People
1B
500M
0
0 15 30 45 60
Months
Run 1
Run 2


Survival Instinct
Survival Instinct Units
200
100
0
0 15 30 45 60
Months
Run 1
Run 2

Considerations

It is important to comment that policies such as reducing the export of grains and fruits are not an explicit part of the model, however we could consider this as a decrease in Grain and Produce Stock for global consumption. In 1816 there probably would not be as great a dependence on exports as in 2024.

It is also important to consider that in 1816 communications were not fast or efficient, therefore there would be a lot of misinformation regarding the reasons for many of the effects. Nowadays we would find out immediately and NASA would be publishing photos in no time. Which would allow better coordination for a global solution.

Finally, Agriculture and thermal technologies are more advanced now than they where in 1916, therefore, if the event happened in our lifetime, we should have different results.

Contribution

We consider this work to be an original contribution to System Dynamics and Systems Thinking as it creates a bridge to the past to obtain insights and better understand our present. In addition, it offers a mechanism to experiment with which the public can better understand their role in a catastrophe of such magnitude; however, this tool will be available until the conference.

For the scientific community in general, it provides a ray of hope, since what System Dynamics offers is not only simulation, but also being able to bring to life the knowledge lost in literature and help humanity not repeat its mistakes.

Conclusions

We have successfully built a quantitative model that behaves like the historical event and reproduces the effects described therein. At the same time, it plays a Stable State when no lever is on. Its structure presents consistency in its units of measurement.

We need to explore the model a little further to understand strategies to mitigate the effects of lack of sunlight in a current environment.

With the current model we can build a game to facilitate experimentation and find the best strategies, as well as explore new scenarios such as the role of corruption.

Next Steps

We would like to present this work and demonstrate the game "Seasons of Survival: From 1816 to 2023". Our game is an adaptation of "The Year Without a Summer" where the player has two scenarios (1918 and 2023), as well as three levels of difficulty where resources, constraints and population vary. Finally, we will explore the role of corruption in this virtual experience.

We cannot share the Online Interface at this time due to Blind Peer Review policy, as it shows author names in the web address.

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