e-ISSN:2582 - 7219

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

Volume 4, Issue 8, August 2021

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 5.928

| ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 5.928|

| Volume 4, Issue 8, August 2021 |

|DOI:10.15680/IJMRSET.2021.0408016 |

Assessment of Ecological Resilience in a Closed Ecosystem using Artificial Life

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ABSTRACT: This research simulates the effects of biotic and abiotic components on a closed ecosystem with or without human intervention. We have assessed the Ecological Resilience of the system through a group of food chain. We have studied the several abiotic compounds in a time regulated manner. We have analyzed various results in a cause-effect relationship by introducing new species, removing existing ones, or changing the concentration levels of current abiotic components. On a global and micro scale, time factoring and control over the biotic gene pool can have an impact on ecosystems. One of the initial and hardest challenges in proposed method Eko is the creation of an independent structure that does not create any unnecessary dependencies so that the perfect balance between independence and interconnection between the abiotic and the biotic elements can be created.This was solved via running a balance between a thread based system and master control for biotic and abiotic parameters. Independent master control takes the simulated drives and values to provide suitable actions accordingly. This saves overhead on processing which is required due to the lack of processing power.

I.INTRODUCTION

Artificial life is a multidisciplinary topic of study that focuses on the production and study of lifelike structures in a variety of mediums (computational, biochemical, mechanical, or combinations of these). Self-imitation, progress, expansion, progression, wisdom, and flexibleconduct are all examples of emergent qualities of life that can be modelled and even realized. Artificial life researchers also seek to learn more about self-organizing structures in general, and to apply the concepts and philosophies to skill development [1].An ecosystem's ability to respond to a perturbation or change by avoiding damage and recovering quickly is known as resilience in ecology. Stochastic phenomena likeblazes, engulfing, storms, bug population blasts, and human actions likedisforestation, drilling for oil mining, pesticides spurted in soil, and the prologueof bizarre plant or animal kinds are examples of perturbations and disturbances. Disturbances of sufficient scale or length can have a significant impact on an ecosystem, forcing it to cross a threshold beyond which a dissimilar set of procedures and organizations takes over [2].Closed ecological systems (CES) are ecosystems that do not exchange matter with any other parts of the organization. The word is most commonly applied to small man-made ecosystems. Such systems are methodicallystimulating and have the potential to act as a life support scheme for astronauts in space, as well as in space stations and habitats [3].The major aim of this effort is artificially stimulating and running numerous parameters under various settings to analyze what goes differently and so live a better future.

II.RELATED WORK

Ordinaryassortment is a basic topic in biology, and the idea of natural assortment has profoundly altered our understanding of biological systems. Similarly, artificial system development is a key section of artificial life, supporting a useful modelling tool as well as an automated design process. In artificial-life systems, genetic algorithms (GAs) are now the most popular and commonly utilized models of evolution. GAs have been utilised as both practical problem-solving tools and methodical models of evolutionary processes[4].GAs are a sort of optimization algorithm that is used to identify the best

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solution(s) to a given computing issue by maximising or minimising a function. GAs are a subset of the area of evolutionary computation [5], in that they simulate biological processes like reproduction and natural selection to find the "best" solutions.With great accuracy, GA was used to assess plant competence in order to decrease wastewater treatment costs in a river basin and increase water excellence [6]. The application of Soft Systems Methodology (SSM) in resolving managerial difficulties has increased in response to concerns about structural complexity, on which different stakeholders have differing perspectives. Due to the limitations of this approach in terms of addressing all points of view and testing the effectiveness of proposed modifications, SSM developed its Fuzzy Cognitive Map (FCM).You can establish a group FCM by merging the viewpoints of multiple professionals while utilising FCM as a modelling tool (GFCM). When it comes to making suggestions and revisions, GFCM has the prospective to be a valuable decision support tool. The ticketing system described in this article is utilized by Raja Passenger Rail as an example of how the technique can be used. The suggested method is used to investigate a system that is influenced by a variety of policies and opinions. After that, suggestions for improving the system are prioritized [7]..

III.METHODOLOGY OF PROPOSED WORK

Methodology:

Even though there have been immense technological advancements, there isn't a tool that would showcase the user interaction within an ecosystem, classification of closed ecosystems, and calculate ecological resilience at the same time. The current tools are incapable of analyzing the ecosystem's behavior to predict possible changes that cannot be seen through naked eyes. The sixth mass extinction is one such case that is greatly debated upon.We have created various scripts that mimic biotic and abiotic components of the ecosystem and run parallel in different threads. Biotic components in these threads have traits such as hunger, threat, libido, etc. Food chains are simulated along with biotic interactions with the abiotic parameters and vice versa. Ecological Resilience is calculated on a time factor basis on various pre-set terms. The user analyzing the changes has the capability of changing the factors which govern the functioning of the ecosystem such as time, the population of a particular species, rates of various abiotic activities, and even the gene pool of the biotic species simulated. The user can also introduce new species, characteristics, and compare various ecosystems. These simulations done on a supercomputer at a microscopic level can predict changes in the ecosystem in timeframes with very high accuracy.

Data Dependencies:

The proposed method "Eko" relies on a set of data modules to produce its output. These data sets are fairly important and highlight the delicacy of the project greatly. With a proper change in values, Eko can be used to simulate various species, with different gene pools as well as extra-terrestrial climates and alien life.

Food Chain:

Eko currently has a 7-species interdependent food chain found in a closed ecosystem. These chains simulate how predators target prey and define the predator-prey relationships inside the ecosystem. This data set can be altered to make complex or simpler chains as well. Figure 1 shows the process of Food chain in an ecosystem.

Gene Pool:

The gene pool refers to the collection of all genes, or genetic information, found in any population, usually of a single species. A vast gene pool denotes a high level of genetic variation, which is linked to strong populations that can withstand periods of harsh selection. Meanwhile, low genetic diversity (see inbreeding and population bottlenecks) can lead to decreased biological fitness and an increased risk of extinction, despite the fact that, as explained by genetic drift, new genetic variants that may improve organism fitness are more likely to settle in a small population. A population is said to be monomorphic when all individuals in it are identical in terms of a specific phenotypic attribute. Individuals are considered to be polymorphism when they exhibit multiple versions of a single characteristic. In Eko each biotic organism has a certain set of traits including but not limited to – health, sexual maturity, life expectancy, hunger tolerance, etc. These pre-supplied

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values can be changed with a newly formed dataset to study the effect of more or less resistance species or species with varied genes on special ecosystems

.**Effect of Patterns of Weather:**

When we talk about weather, we are talking about the status of the atmosphere, such as the temperature, the humidity, the storminess, and the visibility. In the troposphere, a layer of air just below the stratosphere, most weather occurrences occur. Climate refers to the average of atmospheric conditions over a longer period of time. When used without qualifier, "weather" is widely believed to refer to the weather on Earth. Air pressure, temperature, and moisture changes across locations influence weather. These variations might occur as a result of the angle of the sun at any given location, which can change at different locations. Because of how different the temperatures are at polar and tropical regions, the Polar Cell, the Ferrel Cell, the Hadley Cell, and the jet stream are the most important atmospheric circulations. Extratropical cyclones and other weather systems in the mid-latitudes are generated by instabilities in the jet stream circulation. Sunlight falls at varying angles throughout the year due to the tiltof the Earth's axis in relation to the orbital plane of the planet. There are 40 degrees Celsius in the Earth's atmosphere (40 degrees Fahrenheit to 100 degrees Fahrenheit). Solar energy absorption and distribution may be altered by variations in Earth's orbit over thousands of years, affecting long-term climate and global climate change.

In proposed method (Eko) weather patterns have been supplied via pre-defined functions with careful domain range selections. A change in these functions with more carefully thought out and researched methods can lead to better accuracy in the overall results of ecological resilience and the parameters of artificial life over a specified period of time.

Modules: The modules of the proposed system have been described below:

(a) *Resource.py:* This module serves as the base class for Abiotic Cycles for inheritance. Consists of basic conversion methods and getters setters for display and logging purposes.
(b) *Abiotics.py:* This module derives from Resource.py and contains the abiotic cycles found in a closed ecosystem, including the water, carbon, oxygen, nitrogen, sulphur, and phosphorus cycles. It keeps track of the system's constituent components as well as interchanges between different compound types. Figure 3 shows inheritance system for abiotic system and figure 4 shows simplified inheritance system for abiotic system.
(c) *Weather.py:* This module has three classes inside it – Forecast, Sun, and Atmosphere. Sun and Atmosphere inherit the thread class. This module is used to constantly change the weather values like sun intensity or humidity in the environment. Figure 2 shows the inheritance diagram of weather module.
(d) *Biotci.py:* This module has ten classes inside it – Biotic, Jansankhya, Drives and seven organism classes. This module handles biotic urges and simulates the biotic aspect of the ecosystem.Figure 5 shows process of updating organism in a biotic environment and figure 6 shows priority based actions.
(e) *JsonManager.py:* This module is used to parse and save JSON data into the log files.
(f) *Core.py:* This module is the core class of the execution of the program. It defines the initializing, updating and stopping methods of the units of the code along with the time passed and total time values.
(g) *Eko.py:* This module inherits from core.py and is the main module that simulates all the events in the ecosystem. This unit is the master unit and maintains control of execution. This module also calculates the Results.See figure7.
(h) *Display.py:* This module runs concurrently with eko.py to display the values computed by the backend processes running. This also takes care of the UI handles and updates the log values as tampered by the user. Figure 8 shows different atmosphere cycles in proposed system and figure 9 shows working layout of proposed EKO system.

IV.SIMULATION RESULTS AND DISCUSSIONS

The recommended system uses Python as a backend language for creating scripts to run the artificial lives in different threads. The solution simulates Biotic and Abiotic components and their interactions with each other to study and record the effects on a microscopic and macroscopic level. Food chains and artificial life, as well as abiotic environmental

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| Volume 4, Issue 8, August 2021 |

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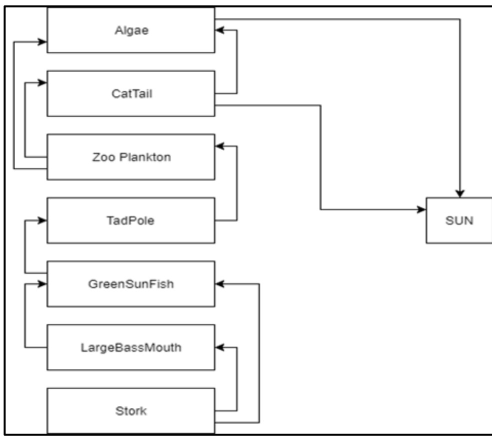
variables, are all simulated.It demonstrates the relationship and interaction of biotic and abiotic environmental components with one another and with themselves, as well as the identification of ecological resilience and classification of closed ecosystems using these characteristics.The front-end part of the project is built using HTML, CSS, and Javascript. It allows users to interact with the framework, the interactions include:(a) changing the time scale, (b) changing population/ amount present of biotic and abiotic components, (c) introduce new species, (d) study a component over time.These features enable users to analyse various different scenarios to classify and study them.



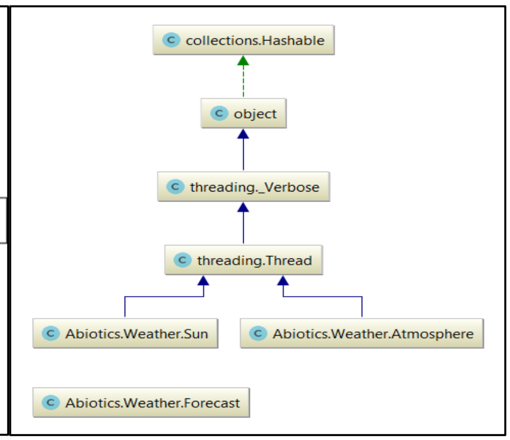


Figure 1: species Food Chain **Figure 2: Inheritance Diagram Weather.py**

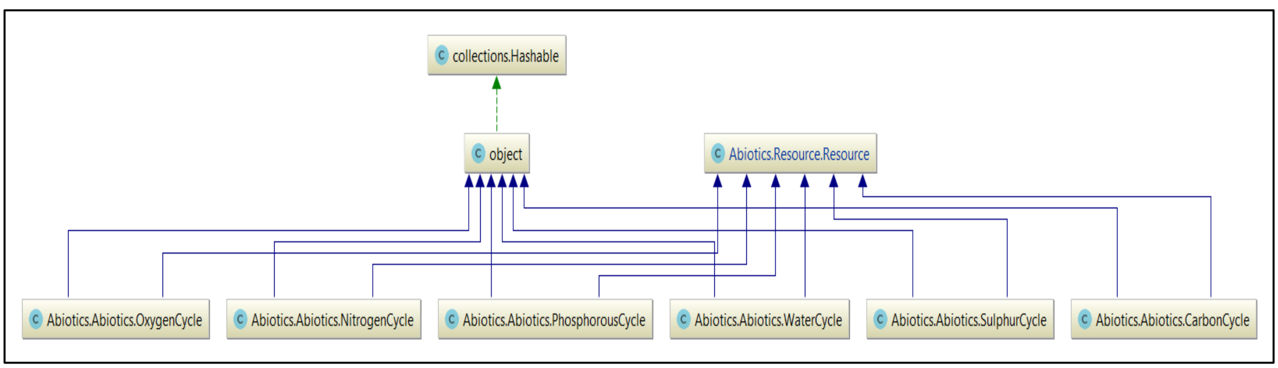


Figure 3: Inheritance system for Abiotics.py

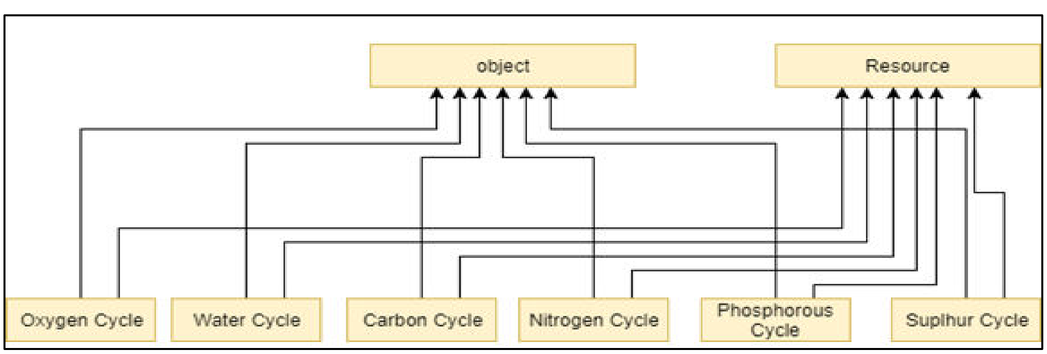


Figure 4: Simplified Inheritance system for Abiotics.py

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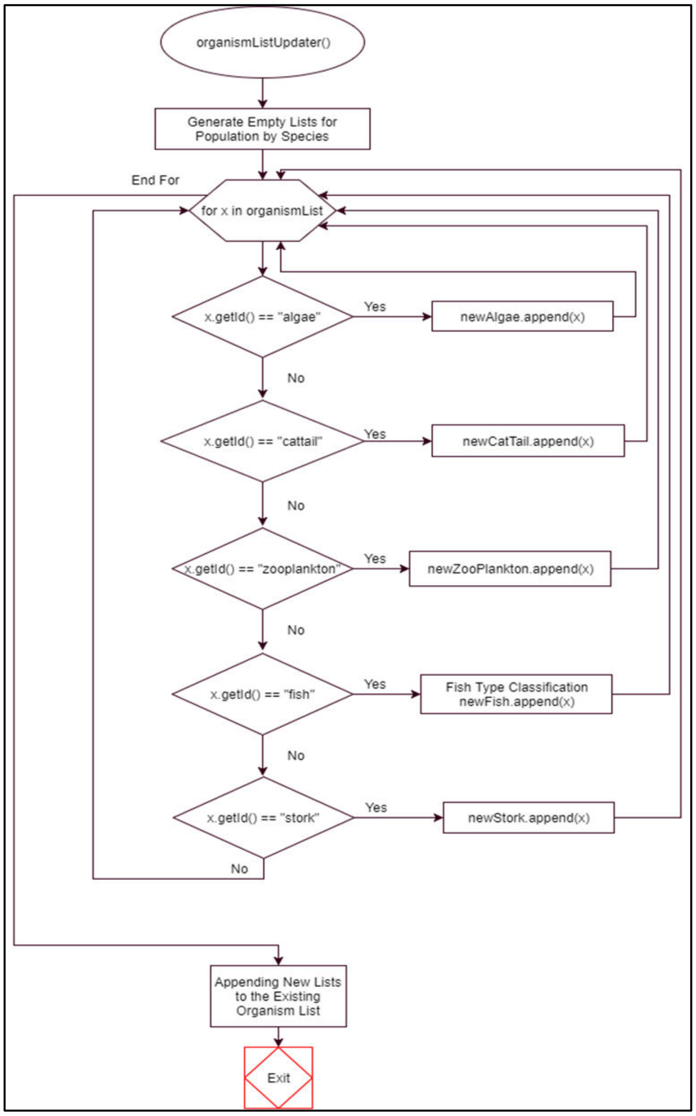

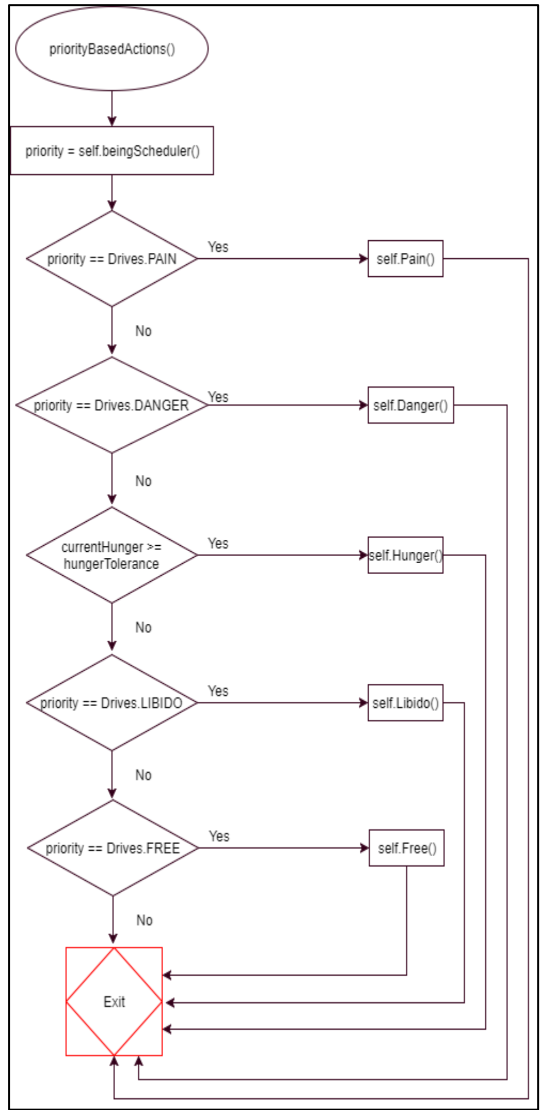

Figure 5: Process of Updating the Organism in a closed Ecosystem Figure 6: Priority Based Actions

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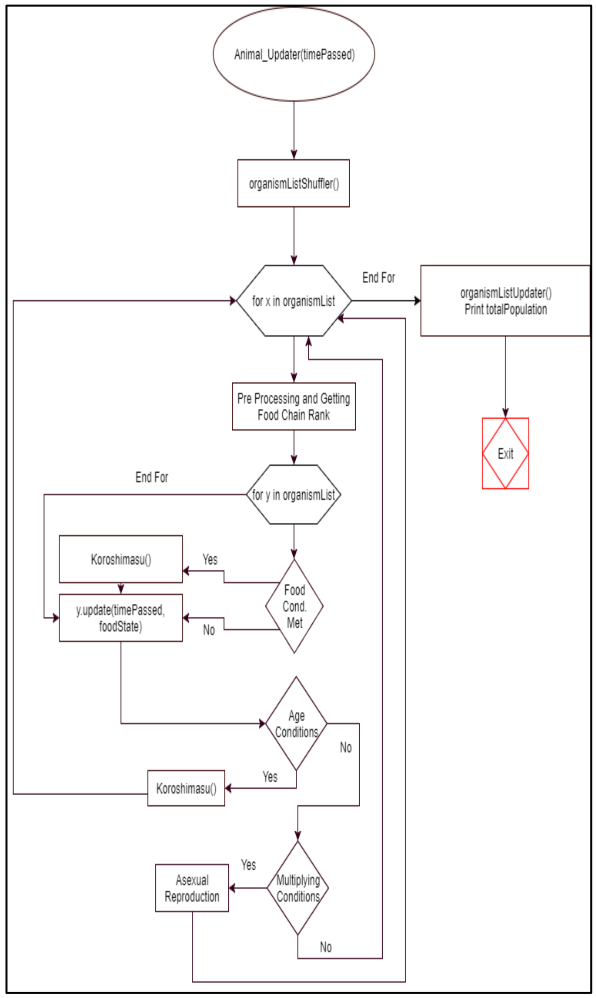

Figure 7: Animal Updater Flow Chart– Eko

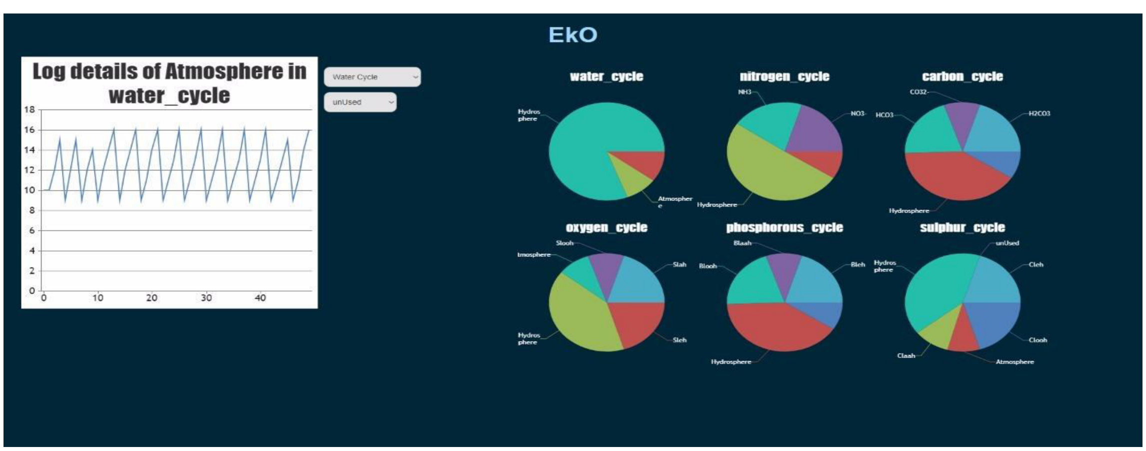

Figure 8: Different Atmosphere Cycles

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|DOI:10.15680/IJMRSET.2021.0408016 |

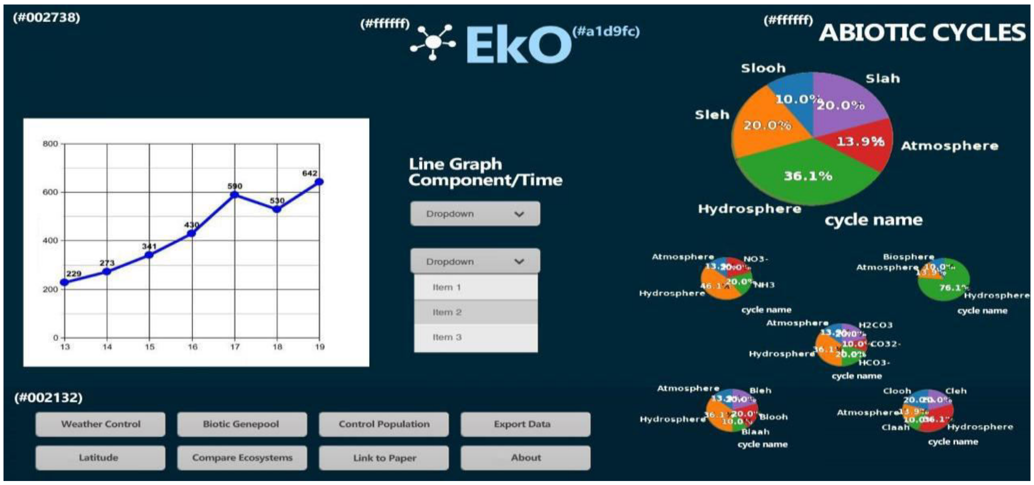

Figure 9: Worklayout of proposed EKO system.

V.CONCLUSION AND FUTURE WORK

The proposed system calls for the use of a thread-based system to accurately imitate varied ecosystems. Random arbitrary changes result in the death of various species and an imbalance in the chemical compound concentrations in nature, whereas balanced ecosystem states are achieved with pre-set values, considerate changes lead to different balanced ecosystems, whereas random arbitrary changes result in the death of various species and an imbalance in the chemical compound concentrations in nature. The project's predefined food chains and animal drives have been brought to life through simulation. PAIN, DANGER, HUNGER, LIBIDO, and CURIOSITY are all basic urges that animals have. Animal gene pools are the driving forces behind each animal's behaviour. When an animal reaches sexual maturity, it multiplies by asexual reproduction. Death is influenced by predator-prey interaction characteristics as well as life expectancy. Throughout the ecosystem, the behaviour of the apex predator in the food chain is highlighted. Ecological Resilience is estimated using concentrations of several biotic and abiotic constituents, and it has been used to classify various closed ecosystems.Panarchy is taken into account when calculating factors like latitude, resistance, and precariousness. Human impacts on closed ecosystems are assessed in the short and long term, and the results are displayed using appropriate statistical methods. All data has been logged and displayed in a user-friendly UI system, and the limitations as well as the potential for future innovation have been highlighted.

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Impact Factor: 5.928

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