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System Dynamics in Rural African context: Focus on Water-Energy-Food nexus

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1. Introduction

The relationship between local rural development and the consumption of energy is not clearly understood or captured. The high degree of uncertainty in the dynamics, the nonlinear processes, and the availability of data must be considered for the characterization and formulation of the electricity-development nexus. It is obvious that a tool is needed that can handle not only the load's unpredictability but also conditions that are connected to socioeconomic factors as well as environmental factors. The WEF Nexus FAO method focuses on the linkages between the systems of natural and human resources [1]. The nexus interaction concerns how we utilize and manage our resource systems considering their interdependence, limitations, and potential for mutually reinforcing or beneficial interactions. To promote sustainability, interagency cooperation, and resource-use efficiency, the ideal nexus approach should include both short- and long-term analysis processes and policy-making that focuses on the connections between water, energy, food, and other related sectors [2]. The paper aims to propose a general, adaptable, and flexible energy demand model to be used at the community level, such as villages and rural areas. The objective is to help NGOs and/or Organization and Institutions in the field, in analyzing future energy planning finding also insights about synergies between different dimensions that will promote the energy-development nexus. To carry out the main purpose of this research project, a system Dynamics based simulation model, has been adopted.

The main issue to be solved, beginning with the description of the problem, is the model's ability to be duplicated in many situations, making the application as general as possible. As the part of the main purpose of replicability and creation of clear guideline for the model application in different context, different parameter classification of the input data is necessary to correctly define their value in application of diverse electrification project. They have been classified in four different categories to know how to approach it: fixed parameters, context dependent parameters, free parameters, and scenario settings parameters.

The village of Rutana serves as the work's intended backdrop. With the method employed in this study, the model can simulate the ex-ante dynamics related to the availability of water and energy in a rural community. The three components of the water-energy-food (WEF) nexus should be simulated together since there is interest in the idea that these sectors are closely linked and function as a single complex system [3].

Different policy scenarios were constructed and simulated over a 20-year period to assess the performance of an electricity project and its consequences for managing water supply for the household and agricultural sectors in the case study. The Income variable clearly states how the project's electrification impacts the attainment of social and economic development as well as the availability of power in the region. These findings suggest that raising income may enhance human wellbeing, while increasing access to clean, potable water and installing irrigation systems may substantially boost already rising income. Health care expenditures will decrease as water availability rises, and agricultural productivity will increase farm income. The affordable connection variable, which is a good indicator of the electrification project's performance, assesses the success of the electrification rate in the rural region. This study has considered the previous analysis' findings about the impact of policy implementation on income. The main objective of this research project was accomplished using a system dynamics-based simulation model developed for long-term electricity demand estimations in rural environments. The System-Dynamic model for long-term power demand forecasts and its effects on the water energy food nexus are also made possible by this. The validation enables for verifying the model structure's capacity to recreate the behavior in a different context and contributes to increasing confidence in the reduced model framework. The results of the policy testing show that promoting self-sustaining socioeconomic growth requires electrification and the development of a water supply distribution network tailored to local needs. Another important finding is that having access to clean water is important for both economic and social reasons because it raises income, which in turn speeds up electrification and its positive effects. Both the effect of model simulation on the goal of the SDGs and the quantitative data gleaned from the simulation have been established. The capacity to access energy is essential for attaining SDG 7. The project's ability to create jobs, which would boost the local economy, raises the possibility of links between poverty and economic objectives. To maximize the electrification project's beneficial effects on rural communities, policy testing allowed for the establishment of best practices, minimal requirements, and supporting activities. This suggests that to ensure the long- term viability of electricity access initiatives, future electrification programs might build on these results to determine the most important issues to address.

Bibliography

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