Design of an integration platform between the water-energy nexus and a business model applied for sustainable development

Heba Ahmed Mosalam and Mohamed El-Barad

ABSTRACT

Setting out an international standard schema for the water-energy-food (WEF) nexus and providing accurate data with realistic reports for investment through a simple application is essential for our real world. This research presents a tool to help anyone who wants to invest in environmental projects, especially water, energy, or food projects. The user can directly connect to a database of environmental data applying WEF nexus principles. This paper is looking for a mechanism to apply the WEF nexus concept through a web-based platform implementing unified concepts and terminology, setting basic criteria and standards, and making the data available, consistent, and homogeneous. Based on the problem statement, the purpose of this research is to implement a cross-application for sustainable development, including WEF nexus concepts, taking into consideration the interlinkage between the three resources integrated with a business model or financial study for projects. In addition, we have determined organizational perspectives of WEF nexus, including government entities, non-governmental organizations, and the private sector, and consolidated all the concepts into one set of WEF standards. Increasing the awareness of WEF nexus will help to establish a new generation of researchers who believe in the WEF nexus concepts and who will coordinate with developers and expert consultants to convert the WEF standards to programming coding.

Key words | environmental platform, GIS, spatial data, sustainable development, Trinex, water-energy nexus

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HIGHLIGHTS

- Feasibility study for new project considering sustainable development.
- Design integration sustainable development water-energy-food nexus with Trinex platform.
- GIS integrated with environmental (water-energy-food) projects.
- Mobile application for investment in sustainable development.
- Spatial environmental data analysis integrated with business model.

GRAPHICAL ABSTRACT

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INTRODUCTION

Many researchers and policy-makers in recent decades emphasized the importance of integration between the sciences, for example, relationships between water, energy, and food, which is called the water-energy-food (WEF) nexus (Barreca *et al.* 2015). The main concern during the literature review is how we examine the WEF linkage and its importance not only in the present but also in the future to ensure that the essential resources of water, energy, and food are considered as one package and are provided in sufficient quality for poor people and fast-developing regions (Bazilian *et al.* 2012).

According to the World Economic Forum (2011), in the next two decades, demand for water, energy, and food will increase by 20–50% for current demand. Therefore, the political and strategic planners and researchers have to consider the interconnections between the WEF nexus in their strategy or problem-solving; otherwise, the world will risk facing severe unintended consequences (Duarte *et al.* 2015).

Recently, the global increase in population and economic development drains the limited resources of water and energy. We need to understand the connections between all resources and also create a qualified generation of WEF nexus academicians and establish tools to help the community with WEF nexus concepts (Trinex platform 2017).

Many WEF nexus studies developed or applied a specific method and tried to adapt it to the characteristics of their case studies (Hamiche *et al.* 2016). In believing that the water crisis is a present and future risk, with the growing demand for local resources, this paper proposes a comprehensive, integrated platform or application between a business model and the water, energy, and food nexus. A platform converts vision to a physical tool to be applied in the real world, helping people and investors take their decision through Trinex 'water–energy–food' concepts (Mosalam *et al.* 2017). It uses a web-based knowledge-sharing system to facilitate cooperation between the investors and researchers.

We propose a cross-application of this process by applying Trinex concepts merged with business models in new projects. We expect that this application will help decision-makers and assist in creating policy. There are lots of existing tools used for water and energy system analysis. However, what makes this research unique is the combination between the WEF and a business model. In addition, this process provides a method for investors to start from data and provide them with analytics and statistics to determine the budget for each element used in the project related to WEF (Dai *et al.* 2018). Sustainable Development Calculator (SDCalculator) is an application combining the water, energy, and food nexus with a financial study in one platform. Water and energy resources, land use, land cover, and many other criteria are loaded into a geodatabase to provide a visible view for the investors and decision-makers, enabling them to make a decision in new projects or develop a strategic plan. This tool is useful especially when the data is linked to the business model or cost analysis for the project. The program takes the financial data related to each location and country and completes the financial calculations in the background of the application without involving the user in the WEF nexus deeply (Sayigh & Al-Jandal 1985). If the user needs to invest in a water, energy, or agriculture project in a certain area, this system will generate a comprehensive study related to the WEF perspective, which will improve the development process. Figure 1 shows the basic idea for the Sustainable Development Calculator Application (Goddek *et al.* 2015).

METHODOLOGY

The main methodological frameworks will be applied and developed by consultant groups of experts in different fields such as water resource management and energy in addition to expert developers who understand WEF concepts. Creating a platform needs two main tasks. The first task is a backend, which involves a spatial database including environmental data needed for the project, for example, water resources, solar density, wind direction, humidity, land cover, and land use. This data is then merged with a business model, which includes information on solar panel cost, pumping, batteries, windmills cost, and other material costs. The second task is a frontend, which involves screen design for the program interface, including pages for 'User Login', 'Dashboard', and other interaction screens. This program can be applied in any area to calculate the project cost. Projects must include WEF nexus concepts. The program has to convert all international standards and sustainable development objectives from a formal context to programming or coding. Data will be updated periodically with freshly acquired and accurate data, ensuring the integration between the different data sets and international standards.

In a digital world, our planet can be represented as layers. Each layer represents a specific phenomenon: 'solar

Figure 1 | Overall project objective.

density, land use, and other criteria' can be named as a 'Thematic Layer' and reflected in the geodatabase. A layer consists of many pixels. Each pixel has only one value in each layer, so when the user selects a pixel or location, the system will return its value. The system is comprised of many thematic layers of natural resources, which helps researchers and potential users to gain a clearer vision for their projects and development targets.

By creating a spatial database that includes the environmental data needed for a project study (e.g. water resources, solar density, wind direction, humidity, land cover, and land use) and merging it with a business model (Tokunaga *et al.* 2015), it can be applied in any area to calculate the project feasibility. Newly acquired accurate data will be used to update the spatial database and program related to the WEF nexus to ensure the integration between different data sets.

Spatial data interprets the world as a large number of pixels where each pixel has only one value. The pixel represents a specific piece of thematic information, and when the user selects a pixel, the system will display the value. For example, if there is a global layer for solar density, each pixel has one value representing the solar density in a specific location.

If the system has many layers for natural resources and information related to WEF, it might contain information for land, water resources, underground water, wind directions, crops, and agriculture. By feeding the database layers determined by specialists and consultants and overlapping all layers, the system can select and rank the best location for the investment of a specific project. Figure 2(a) represents the basic concept of ranking.

The combination of a business model and resource information will create a system that takes into consideration both technical and financial issues while respecting the sustainable development concepts and WEF nexus approach. Figure 2(b) clarifies the idea of merged layers in the system.

There are many methods for creating layers, including field data gathering, trusted web sites, and governmental cooperation. It can also be done using automated approaches, including interpolation, to determine missing data, or using expert systems to predict the future cost of projects based on the cost of past projects. The system will cover international standards for water, energy, and food, which will help to create WEF standards in the future.

CHALLENGES AND OPPORTUNITIES

Opportunities

The main opportunity for this application is to be a leader for automated WEF concepts and have these concepts applied in real-world situations. In addition, it will have an overview of sustainable development and investment in

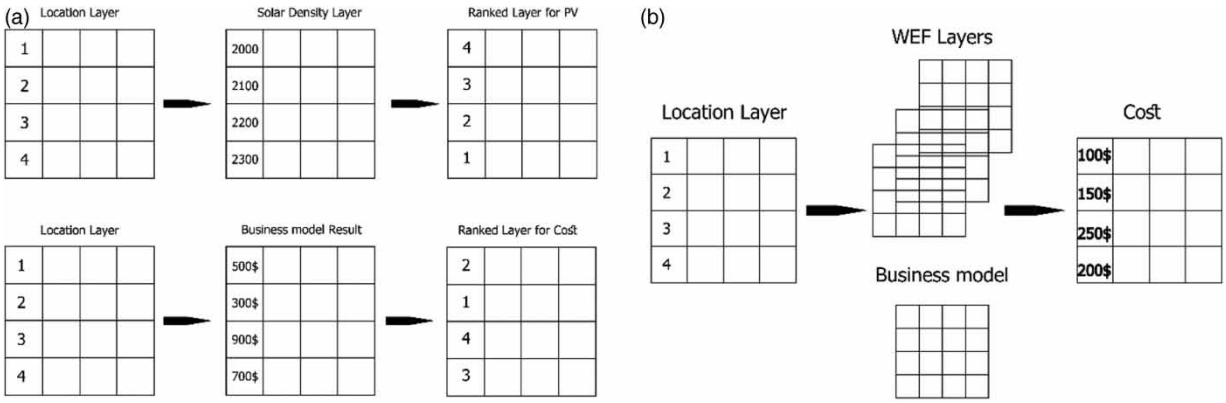

Figure 2 | (a) Ranking Idea. (b) Idea of merged layers system.

Figure 3 | Application Workflow.

the world or each country. This overview could be used as a tool to support national strategic planning in developing countries. This application also predicts that water, energy, and food standards will be merged to create a new standard specification for the WEF nexus.

Challenges

Data gathering is one of the main challenges with this application. Also, cooperation with government agencies and civil society organizations will be essential to ensure the effectiveness of the application in a wide range of locations. Implementation for a platform will not take much time as the enhancement and modifications for database schema and relations due to the updates comes from the consultants and researchers. Also, integration between business models or financial studies with the three different resources is a great challenge.

Application workflow

We expect there will be various functionality in the system; when the investor selects the calculator button, the world map will appear to select the area for investment. After the investor selects the area, they will choose the field of investment 'Water-Energy-Food', then they have to fill the application form depending on the field of investment. Figure 3 represents the application workflow. The application will calculate the expected costs, and the user will find a report and recommendation according to the database created.

The system will be available on both desktop and mobile devices, and uses an enterprise geodatabase, with an impressive and effective design for client comfort. Figure 4 represents a proposed draft design of the screen. Figure 5 shows the login interface for tablet, mobile, and desktop devices. After the user login, there are many options, like getting specific data or statistical data for a certain area or project. Also, the user can navigate with specific criteria. The first function is to calculate the cost for a project considering the WEF nexus and sustainable development. Figure 6 shows the proposed dashboard screen.

The first step is to select a specific area by selecting a location on the map or using GPS, writing an address, or even by location coordinates. Figure 6 shows the site selection screen. After selecting the project location, the system will open an application form, and the user will fill in the form related to the project.

According to the investor interest, they will select the field they want like 'Water-Energy-Food', and the form will depend on the type of project, as illustrated in Figure 7. Then the user has to fill in the needed data, for example:

- Discharge needed for a water project
- Capital needed to cover
- Total megawatts needed for an electricity project.

Finally, the report will process according to the WEF perspective considering international standards by integrating sustainable development of the WEF nexus with its cost. Figure 8 represents the proposed report template screen.

- Reports will be per element to provide the user with a view for the budget needed.
- Reports will be validated and verified in the beta version.

RESULTS AND DISCUSSION

Effective system design and management, considering the interlinkage between our resources, water, energy, and food, is essential and critical for sustainable development at all scales. An in-depth analysis of the nexus system, like the relationship between energy flow and water, can improve understanding of the quantitative relationship between the two resources, which helps decision-makers and researchers develop optimized outcomes and minimize risk (Dai *et al.* 2018). Sustainable Development or SD Calculator Application is pivotal to sustaining and improving the quality of life. For example, the discovery of new areas for

Figure 4 | Proposed screens.

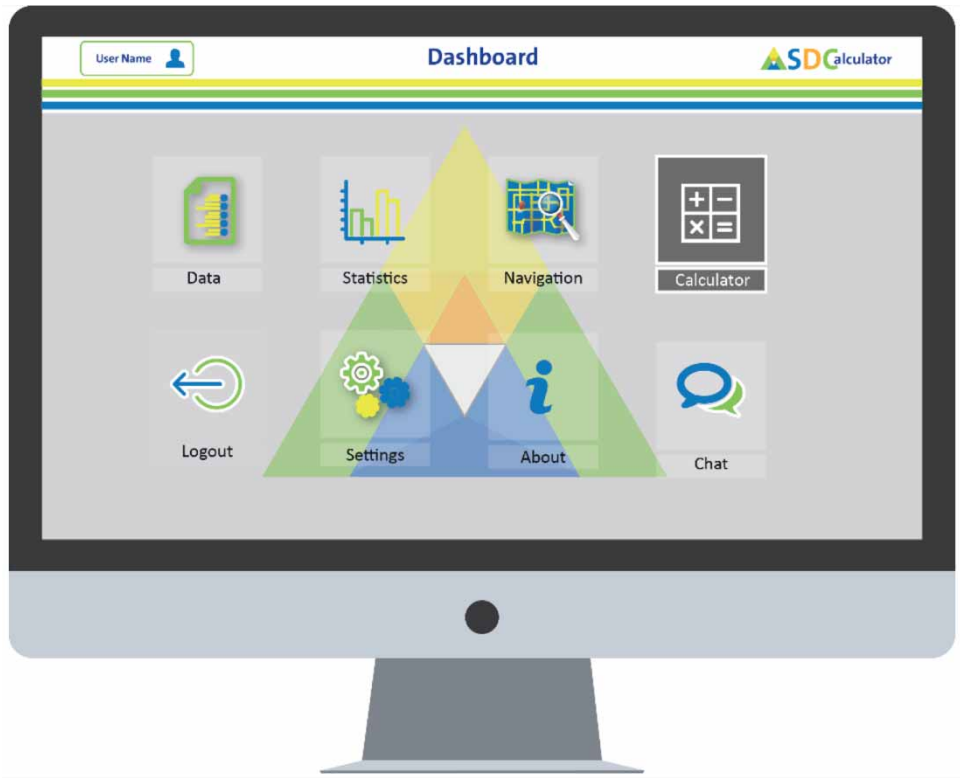

Figure 5 | Dashboard screen.

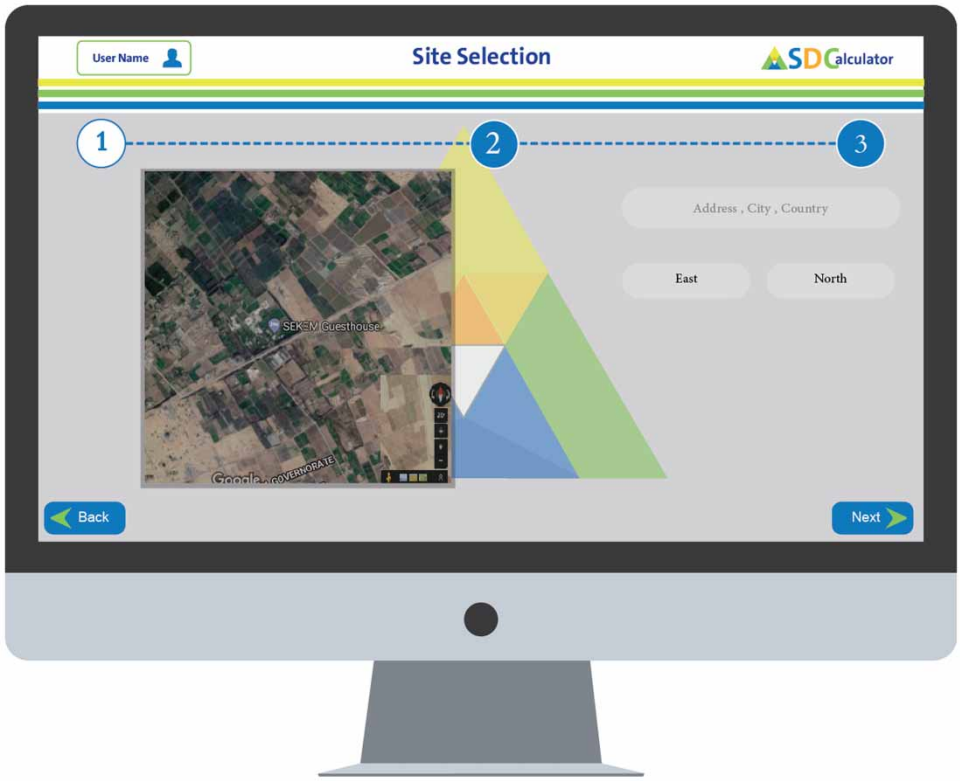

Figure 6 | Site selection screen.

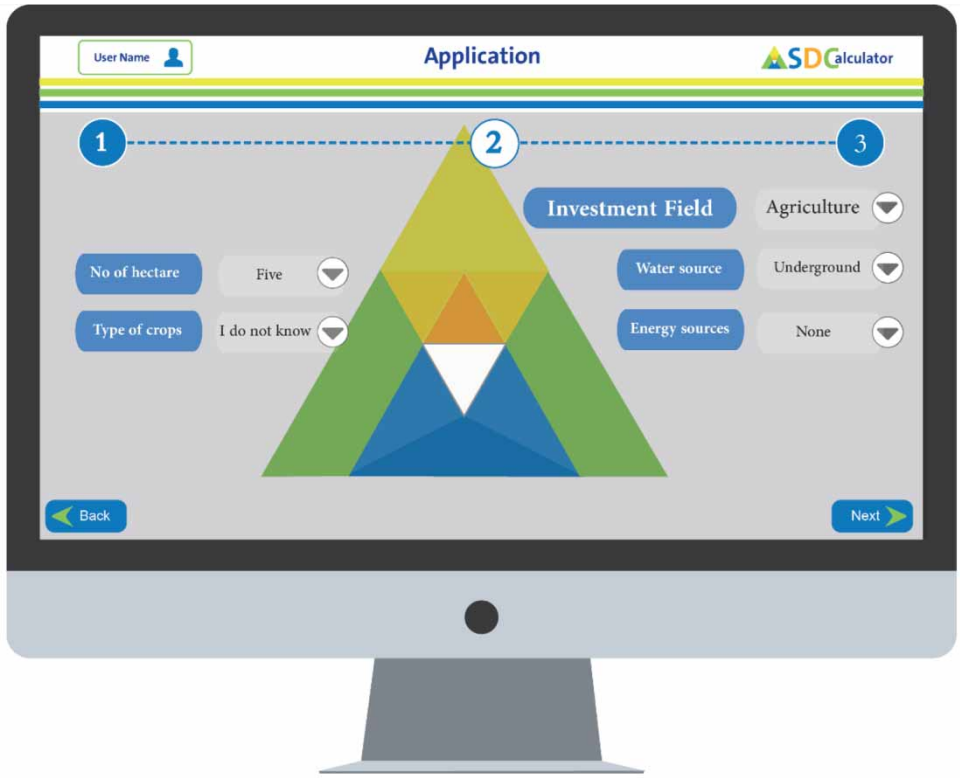

Figure 7 | Illustration of an application form.

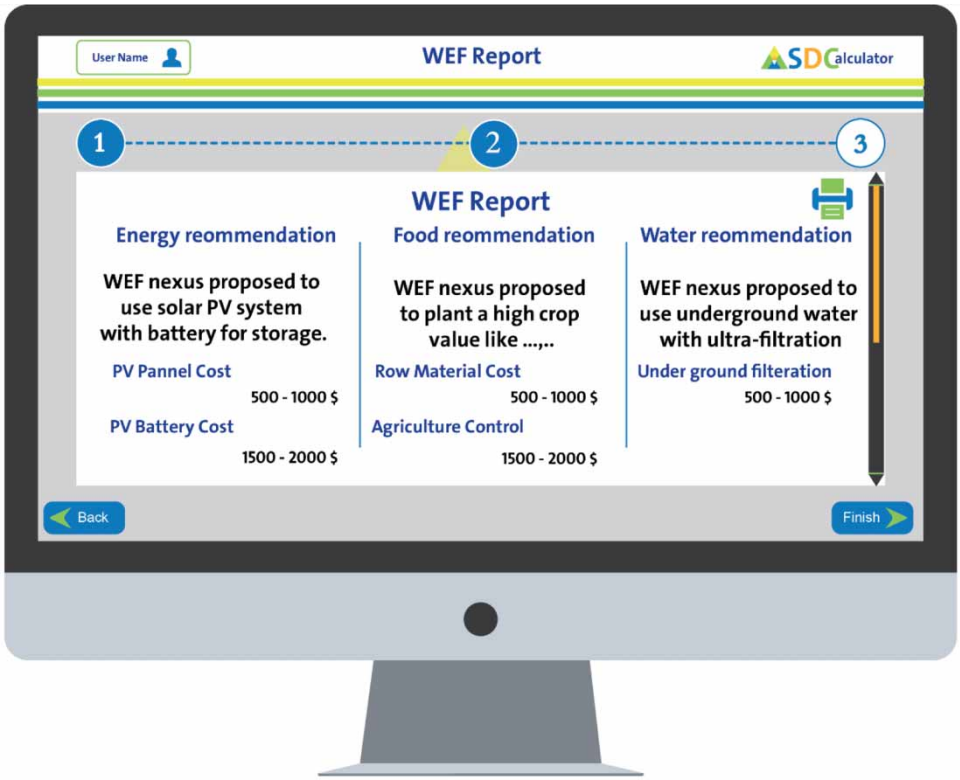

Figure 8 | Representation of the proposed report template screen.

investment in solar energy or for producing a specific type of food. These discoveries lead to development projects that increase incomes and build new development in communities based on the best use of water resources and using renewable energy to produce food.

CONCLUSION

The SD Calculator will be a unique tool for sustainable development. The idea of putting an environmental platform in a leading position for applying the WEF nexus approach is unique; it combines three different field criteria in an automated system integrated with business needs for budget calculations. If an investor needs to build his project in the desert, the system can provide the best location in this area. The choice advised by the system would be based on the irrigation methods, the power requirement, and water resources available according to the linked databases and expert-system. The final result would be an estimate of the budget required for this project, and a report can be generated on the sustainability and level of adherence to the WEF nexus. Additionally, after a while, it can be an expert system that calculates any area automatically and precisely. There are many objectives for the application: (1) providing separated data for the investors or users; (2) providing statistical data for investors; (3) sending mail or chatting with consultants; (4) a specific system that calculates the cost to invest in a particular area considering the WEF nexus and sustainable development aspects.

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