RESEARCH ARTICLE

SABRAO Journal of Breeding and Genetics
55 (4) 1271-1283, 2023
http://doi.org/10.54910/sabrao2023.55.4.20
http://sabraojournal.org/
pISSN 1029-7073; eISSN 2224-8978

GREENHOUSE COST INDEX METHODOLOGY BASED ON THE DIVERSE REGIONS OF IRAQ

H.H. AL-ASADI*, N. GOGA, and M. MANDANA

Faculty of Automatic Control and Computers, Politehnica University of Bucharest, Bucharest, Romania
*Corresponding author's email: hanan.h.lafta@uotechnology.edu.iq
Email addresses of co-authors: n.goga@rug.nl, falahi.mandana@yahoo.com

SUMMARY

Greenhouses have become widespread structures that create an ideal microclimate for growing crops worldwide. A greenhouse is a structure that allows people to regulate climatic conditions, such as, temperature and humidity. There are many different designs of greenhouses, but generally, these buildings include large areas of transparent material to capture the light and heat of the sun. They also offer protection from unfavorable weather conditions and pests, providing a popular solution for crop production worldwide, including Iraq, which uses alternative energy sources for climate control. Using machine learning models has helped design different greenhouse types; however, their ability to predict costs and designs based on features is yet to exist. Therefore, to address these issues, this study aimed to develop cost-effective and user-friendly greenhouse systems through two different approaches: Firstly, the use of random forests (RFs) model with the highest precision (0.99) formulated the cost of the greenhouse for new input data to calculate a greenhouse cost estimate based on the system's performance as a benchmark while selecting the greenhouse's features through training and testing, and secondly, the use of the farmer's desired price as a basis for developing a greenhouse design. This scientific approach will enable the farming community to manage the costs of various aspects, such as, building materials, energy sources, climate control devices, water and fertilizer delivery, growing substrates, internal logistics, and labor. The presented research will provide farmers with a practical basis that also considers the constraints, i.e., the economy, climate, law, market, and resource availability. It will empower the farmers to make the right decisions regarding greenhouse systems with their specific requirements and circumstances.

Keywords: Greenhouse systems, agriculture engineering, greenhouse designs, climatic conditions, controlled environment, computer engineering

Key findings: With a package of verified information, the farming community can manage the costs of various aspects, such as, building materials, energy sources, and climate control devices. It will aid them in making the right decisions regarding greenhouse systems that suit their specific circumstances.

Communicating Editor: Prof. Naqib Ullah Khan

Citation: Al-Asadi HH, Goga N, Mandana M (2023). Greenhouse cost index methodology based on the diverse Regions of Iraq. *SABRAO J. Breed. Genet.* 55(4): 1271-1283. http://doi.org/10.54910/sabrao2023.55.4.20.

Manuscript received: April 5, 2023; Accepted: June 9, 2023.

INTRODUCTION

Agriculture has closely merged with human life and activities for centuries, evolving from traditional farming to modern production technologies. Identifying the factors that have a positive impact on greenhouse design has become imperative in light of the numerous benefits offered by these structures, such as, longer growing seasons, reduced input use, less risk of crop loss due to biotic and abiotic stresses, and off-season crop production (Al-Asadi *et al*., 2022). Climate change posed a challenge in producing certain crops, making it necessary to design multipurpose greenhouses with features and control on ventilation, temperature, moisture, and plant growth analysis worldwide, including in Iraq (Rohimi *et al*., 2019). A well-designed greenhouse must maintain optimal ventilation and temperature to support plant growth and development, which can be achievable through the climate management system (Mahmud, 2021).

In the hot summer, the greenhouses can serve as a means to cultivate crops, maintain them at the ideal temperature, and receive an uninterrupted flow of irrigation water. Employing a sun-tracking mechanism can establish a climate control system to regulate the greenhouse environment and maximize solar radiation throughout the day. Such a climate control system will guarantee to keep the temperature stable and conducive and manage the water supply to optimal plant growth within the greenhouse (Al-Asadi *et al*., 2022).

The presented study aims to establish the cost index of a practical greenhouse by converting observations and factors into numerical data and performing various statistical analyses, such as, data compilation and multivariate analysis through coefficient and regression analyses and structural equation modeling. Assessing all these factors is crucial to understand the farmer's requirements and effectively interacting with greenhouse systems to promote sustainable agriculture. The study will also identify and validate end-user needs of the proposed greenhouse-based farming system, formulate the greenhouse cost estimate by selecting the greenhouse's features, and predict the greenhouse design based on the farmer's desired price. The information used in the valuable study came from 63 marketing centers from July 2021 to September 2022.

A discourse on the solutions to create an intelligent, cost-effective, and adaptable agriculture system that farmers can adapt according to their plants' environment can transpire herein. These solutions will utilize smart technology to monitor, analyze, and control different aspects of the plant's environment, creating a clever system that can promptly respond to the variations in the surrounding environment. It will also enable the farming community to adjust their plants' atmosphere more efficiently, ensuring optimal growth with good health.

Rohimi *et al*. (2019) studied the feasibility of a small greenhouse building with a ventilation system for best seed germination, plant growth, and cloning. They emphasized monitoring and controlling the system to lower the greenhouse temperature and observed that the air ventilation design could significantly differ in lowering the inside temperature. The researchers also ably regulated the climate in the greenhouse, creating an optimal environment for growing plants using automated monitoring and control systems. Choab *et al.* (2021) investigated the influence of greenhouse design factors on thermal behavior and energy requirements for heating and cooling using TRNSYS (transient system simulation tool) dynamic simulation. They also validated the TRNSYS simulation model with an annual heating demand error of 1.66%.

With soil degradation, climate change, salinization, and water scarcity in Iraq, the agricultural sector faces numerous challenges, and therefore, past studies recommended developing innovative agriculture strategies to sustainably improve the sector as it contributes significantly to the national economy (Mahmud, 2021). Kondaveeti and Mathe (2021) analyzed 130 past reviews for the past 15 years to categorize them based on the success rate of prototypes using Arduino for electronics research. Despite limitations in processing speed, storage capacity, and hardware, the researchers concluded that Arduino could still provide users with the creativity to develop customized projects.

Past findings made it well-known that progressive agriculture and farming systems utilize various advanced production technologies to make farming more cost-effective, profitable, and comfortable. However, existing traditional farming systems must address some limitations, such as, farmers' inability to change these, lack of cost transparency, and the effect on design parameters. This study proposed 1) to use a greenhouse cost index for the agricultural sector, 2) to predict greenhouse design based on farmers' desired cost by choosing greenhouse features, and 3) to confirm the end-user needs for the proposed greenhouse-managed farming system. The projected system can precisely formulate the cost of materials after considering the salient design parameters using machine learning and data analytics.

The presented study covers a) a discussion on sustainable agriculture design and its challenges, b) a review of the greenhouse design approaches used in past studies, c) proposing five methods for greenhouse cost and design, with results' analysis, d) a comparison of the indices generated and requirements derived from the various methods used to visualize the greenhouse cost and design, and e) a conclusion with recommendations for future use.

MATERIALS AND METHODS

The methodology and data compilation of the various automated greenhouses involved engineering designs' use to determine the suitability and cost of greenhouses based on temperature fluctuations and crop growth during the blazing summer. It affects the greenhouse quality, growth, and productivity, which can be improved using larger ventilation holes, shade nets, different greenhouse styles, and automatically opening windows (Mahmud, 2021; Mehta *et al.,* 2021). The developed design arose from existing simple greenhouses and modified units to suit the Iraqi climate by improving air ventilation and reducing trapped heat. The cost and layout of the greenhouse mainly resulted from various factors, including material availability, price, outdoor use of the material, and the management of shade, irrigation, ventilation, and heat (Mehta *et al*., 2021).

The cost of a greenhouse per square foot varies depending on its type and design, with an average range of USD 5 to USD 35. The height and width of the greenhouse have a weighty impact on cost than its length, and the type and design of the greenhouse and the materials used also affect the total cost. Building hobby and backyard greenhouses can be possible in any size and function well and have options for constructing complex greenhouses with storage, shelves, and workspace (Figure 1).

The greenhouse frame can consist of metal, PVC, and wood, with metal and PVC as the most commonly used material (Figure 2). The greenhouse covering, known as glazing, allows sunlight in while protecting the plants and regulating temperature and humidity (Choab *et al*., 2021). The type of glazing used depends on the location and crops grown in the greenhouse, and its durability is also a factor to consider. Some farmers may add insulation to the greenhouse, depending on their needs and the type of glazing used (Figures 3 and 4) (Choab *et al*., 2021; Mehta *et al*., 2021). The greenhouse doors are also necessary for temperature regulation with a stiff frame and glazing (Figure 5). A greenhouse has the sun as heat, while a hothouse has a heater. Some individuals may choose to cool their greenhouses in hot summer, depending on the crop type grown (Figure 6) (Al-Asadi *et al*., 2022).

A watering and misting system installation can also help keep the soil moist

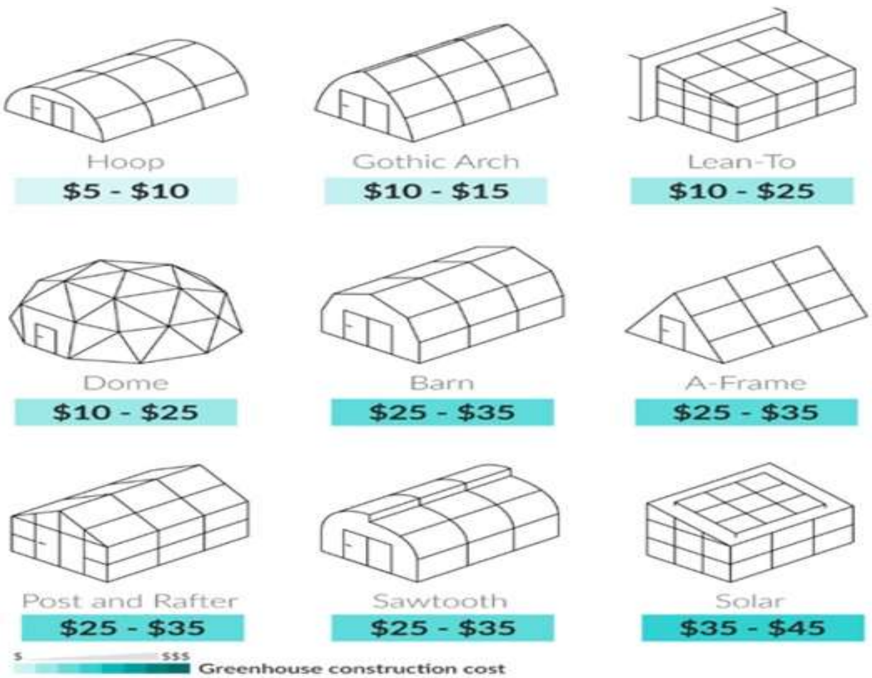

Figure 1. Construction type cost (USD).

Figure 2. Cost of construction material (USD).

Figure 3. Construction glazing cost (USD).

Figure 4. Construction insulation cost (USD).

Figure 5. Construction door cost (USD).

Figure 6. Construction cost by the cooling method (USD).

and the required level of humidity, with an average cost of USD 50 to USD 100, depending on the size and area of the greenhouse. Excavation may be necessary to level the land, with a price per square meter of USD 2 to USD 5, requiring an electrician to run power tools with the required lights at USD 75 to USD 150 per month Computations for most greenhouses in square meters include the cost of construction, materials, and excavation. Greenhouse cost, design, and performance specifications follow below:

a. Definition of the required functions for building a greenhouse

A diagram showing the structure of a greenhouse, including all its essential features and operations, appears vertically in Figure 7. The functions of the greenhouse cover include energy storage, heating of greenhouse air, dehumidification, cooling, prevention of energy loss, sunshade, and design and size. These are the minimum requirements for running an energy-efficient greenhouse. Each of these features presents its unique challenges and hence, a range of solutions, shown along the horizontal axis of the diagram (Cañadas *et al*., 2017; Mehta *et al*., 2021). For instance, cooling can also happen through natural ventilation through a fog system within the greenhouse, cooling the greenhouse cover with water, pad-and-fan cooling, and heat exchangers using soil and outdoor air.

b. Performance specification of the design

The operating specifications of a system in an automated greenhouse consist a performance specification document. A comprehensive specification, including instructions, materials, performance, dimensions, and other critical details, is crucial for an automated greenhouse to meet the needs and demands. In summary, specifications play a vital role throughout the design phase and are essential for the tangible results of this research. The prime characteristics of performance specifications are in Table 1.

Derivation of conceptual designs

The proposed system aims to provide farmers to choose a greenhouse design that meets their specific needs without requiring extra time and effort. There are no limitations to the number of possible designs to develop, and the farmer can also easily design their desired greenhouse using this platform. Figure 7 illustrates three different blueprints, and the farmer can create one based on their requirements and considering the cost index. This approach also allows the farming community to have a more cost-effective greenhouse design that suits their needs, ensuring optimal plant growth and maximizing yields.

Table 1 presents the values of the variables used in the regression analysis, which ran to determine the total cost of the greenhouse with a specific design. The equation used for this analysis was:

$$\text{GH Cost} = \beta 0 + \beta 1(\text{Landsize*M2}) + \beta 2(\text{C\_Design Style}) + \beta 3(\text{C\_Material}) + \beta 4(\text{C\_Door\_type}) + \beta 5(\text{C\_Glazing}) + \beta 6(\text{C\_Insulation}) + \beta 7(\text{C\_Power}) + \beta 8(\text{C\_Sense\_Data}) + \beta 9(\text{C\_Control\_Temp}) + \beta 10(\text{C\_Control\_Hum}) + \varepsilon \quad (1)$$

Where:
GH cost is the total greenhouse design cost, $\beta 0$ to $\beta 10$ represent the relative cost of each factor, and ε is the constant cost of the control type used in the design.

All the obtained data came from real-world sources, including marketers and farmers in Iraq, and comprised 1,091 entries, then analyzed. Comparing followed the cost of a standard 70-square-foot greenhouse, which typically includes polycarbonate glazing, a hoop style, a single large door, steel material, two to three big fans, and bubble wrap insulation, with retails averaging USD 1,500. The summary statistics of the data are in Table 2.

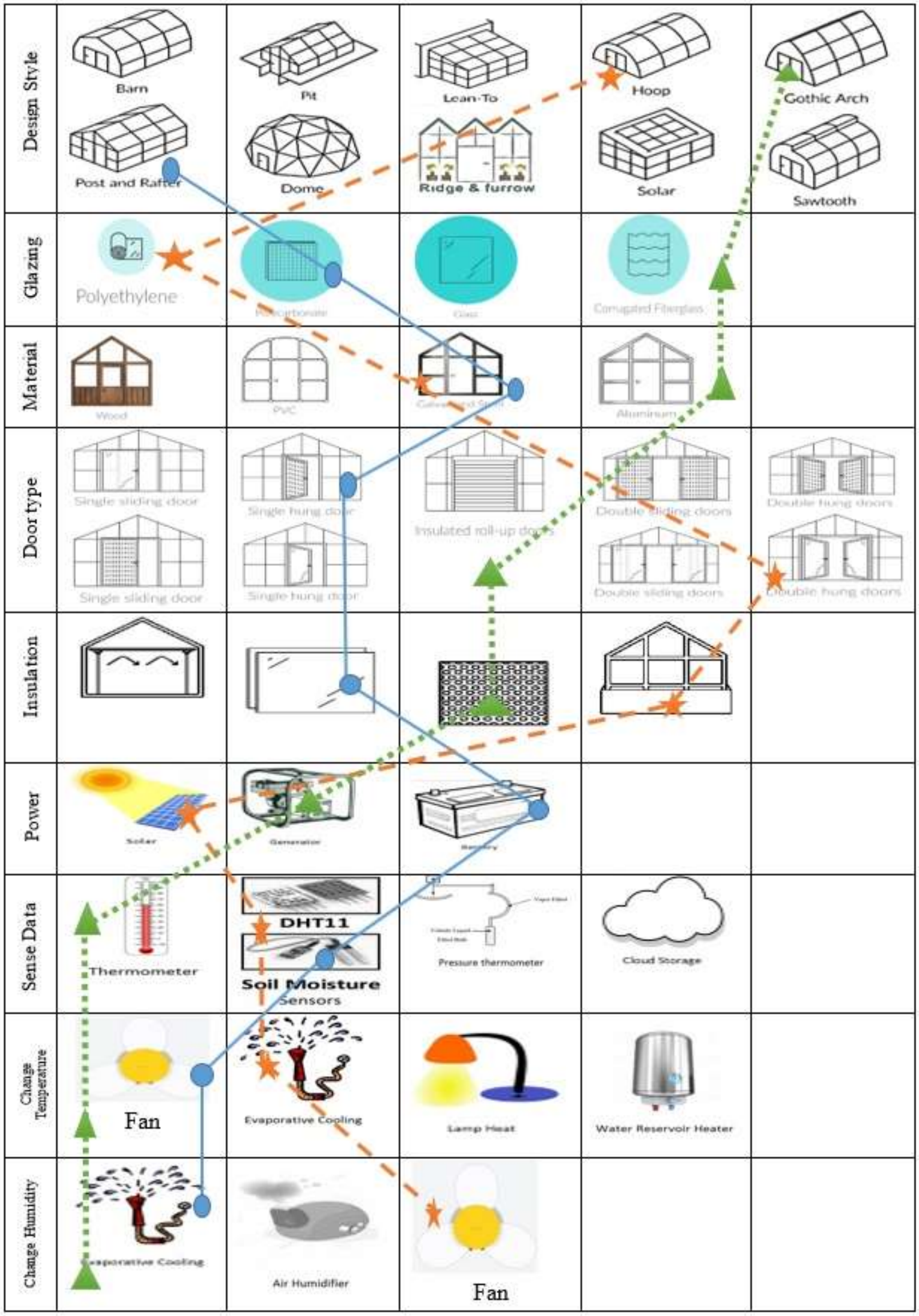

Figure 7. Cost structure diagram for greenhouse construction.

Table 1. Greenhouse design performance specifications.

Specification	Characteristic	Allowable Variation in Characteristics
Greenhouse design	Hoop	Moderate
Frame material	Wood	Moderate
Plant cover	Plastic	Not expensive
Typical size of a greenhouse	Width, length, height	M^A
Management and surveillance apparatus	Arduino	Simple
Sensors controlled by an Arduino	DHT-11, ESP8266, soil moisture, water level, LDR	Simple
Mechanisms for climate control	Turn on the fan, the ceiling fan, the sprinkler system, and lift the roof	Moderate
Administration	Android application and website monitoring	Good and simple to use
Outdoor purposed	Aluminum, steel	Good for harsh environment

Table 2. Descriptive statistics of prices.

Variable	Mean (USD)	Std (USD)	Min (USD)
Greenhouse Size (GHS)	185.256	121.204	1
Average Greenhouse Size (AGHS)	9262.81	6060.22	50
Average Style Cost (ASC)	29.3487	9.19513	10
Average Material Costs (AMC)	2.23802	0.42587	2
Average Glazing Costs (AGC)	1.99127	1.22548	0
Average Insulation Costs (AInsC)	3.27992	0.44897	3
Average Door Costs (ADC)	1027.62	211.041	800
Average Heating Costs (AHC)	37.6616	4.41954	35
Greenhouse Price USD (GHPD)	10365.2	6063.91	900
Greenhouse Price Dinar (GHPN)	1.55E+07	9.10E+06	1.35E+06

Simulation of cost prediction for greenhouse design

The use of a systematic design approach generated cooled greenhouse concepts. First, defining all the requirements focused on three main priorities, i.e., maintaining a daily temperature of a maximum of 26 °C, effectively utilizing resources and ensuring proper ventilation, and cooling as and when needed. The vital functions for meeting all these requirements, identified through system analysis, included ventilation, cooling, shading, heating, dehumidifying, and maintaining the indoor climate (Alahudin *et al*., 2018).

Various operational theories cropped up for each function (Figure 7). The farmer received two options for building the greenhouse— either using the cost prediction model or the design prediction program. A more detailed explanation of each option occurs in the coming section. The cost prediction model enables the farmers to predict accurately the cost of materials for their desired designed greenhouse. On the other hand, the design prediction program allows the farmer to put their budget and other requirements, and the system will automatically generate a greenhouse design that will fulfill those required parameters.

a. Cost prediction model

The development of a greenhouse cost prediction model envisaged the greenhouse cost based on the Iraqi greenhouse dataset obtained from Iraqi marketers and the Ministry of Iraqi Agriculture, found in a Jupyter notebook. The checked model for advancing used various machine learning algorithms, including linear regression models (OLS, Lasso, Ridge, Elastic Net, and Bayesian), as well as random forests (RFs) and decision trees (DTs) (Mehta *et al*., 2021). The process was the

Table 3. Explained variance scores.

Model	Variance Score	MAE	MSE	R-Squared
OLS	0.9997908	11797.1777	193879.855	0.9997693
Ridge	0.9997432	11797.1887	193883.814	0.9997605
Lasso	0.9997556	11797.1738	193882.762	0.9997636
Bayesian	0.9997197	11797.4066	193851.203	0.9997197
ElasticNet	0.9997869	11798.3757	193883.157	0.9997687
Dis_Tree	-	11904.8032	197977.602	0.9997606
Ran_Forest	-	11902.9092	197981.496	0.9997698

Table 4. The price affecting four attributes.

Attributes	Def- attributes	Values
AMC	Material-Type	0.000102
ASC	Style-Type	0.001422
AInsC	Insulation Material	0.005559
GHSize	Greenhouse Size	0.999388

same for all algorithms, i.e., the method defined, the training set variables fitted into the process, and test set forecasts prepared. The model with the highest precision served to formulate the cost of the greenhouse for new input data. The performance summary of each method appears in Table 3.

b. Predict the greenhouse design program

Greenhouse design provides a means to manage internal weather conditions and to create optimal conditions for the best plant growth and development. The design must also consider a wide range of factors, including construction materials, energy, management, weather control, water, fertilizer, growing media, and labor, to ensure the efficiency and effectiveness of the greenhouse.

Despite the importance of the farmer-suggested greenhouse cost, a less understanding of how it relates to the predicted design exists. In addressing this, employing a Naive Solution can generate all the possible construction variables and compare their sum with the suggested cost (Mairing, 2017). The method also showed how the size, design, material, and insulation can impact the total cost of the greenhouse (Table 4). The algorithm creates every possible combination of these four variables and compares their sum with the farmer's suggested price of the greenhouse (Figure 8). The time complexity of this algorithm is O(n)4, and its space complexity is O(1). The time complexity gets determined by the number of loops in the algorithm, which takes O(n)4 times to process, with the space complexity determined by the size of the inputs and cannot be less than O(n) (Muñoz and Moguerza, 2005; Mairing, 2017).

RESULTS AND DISCUSSION

The trials of the proposed study programs occurred in different scenarios and elements to ensure their viability for real applications as a climate control system that will guarantee to keep the temperature stable and conducive and manage the water supply to optimal plant growth within the greenhouse (Al-Asadi *et al.*, 2022). Some critical elements, such as, greenhouse size (GHS), average style cost (ASC), average material cost (AMC), average glazing cost (AGC), average insulation cost (AInsC), and average door cost (ADC), have also been considered in the implementation. There were two main approaches: first, to measure the performance of the system by training and evaluation of the results, while choosing the greenhouse size with average costs of design, material, glazing, insulation, doors, and cooling system using different linear

```
// Input: the value of x entered by message box ("Enter Average price of design:")
         : the CSV data "costgreenhouseprice.csv" used to calculate the four output values
//Output: the values of GHSize GHS, Style-Cost ASC, Material-Cost AMC, Insulation-Cost
AinsC
Begin
Define CSV library
Set directory of CSV data
For each file in a directory do
    Get directory list
    Set pathname= path+"costgreenhouseprice.csv"
    Read CSV files
    For each CSV file do
        Initialise x=0
        # Converting GHSize column to Gs list
        Gs = df['GHSize'].tolist()
        # Converting Style-Cost column to Sc list
        Sc = df['ASC'].tolist()
        # Converting Material-Cost column to Mc list
        Mc= df['AMC'].tolist()
        # Converting Insulation-Cost column to Insc list
        Insc = df['AInsC'].tolist()
        DISPLAY ("Enter Average cost of design:")
        x <- INPUT ()
        # Change that string to a float
        Our_input := float(x)
        Call FindElementsDesign(Our_input, A, n) function
    End for
End for
A = Gs + Sc + Mc + Insc
n = len(A)
Def FindElementsDesign(Our_input, A, n)
Initialise i, j, k, 1=0
#Find the first component and look for the other three.
For i in range(0,n-3) do
#Find the second component and look for the other two.
  For j in range(i+1,n-2) do
#Find the third component and look for the fourth.
      For k in range(j+1,n-1) do
#Find the fourth component.
          For l in range(k+1,n):
              If A[i] + A[j] + A[k] + A[l] = = Our_input, Then
              Do print ("%d, %d, %d, %d"
                        %(A[i] "GHSize", A[j] "Style-Cost", A[k] "Material-Cost", A[l]
"Insulation- Cost"))
             Else for all A[i] + A[j] + A[k] + A[l] <> Our_input
             Do print ("Sorry, change your average cost for greenhouse design: ")
             Endif
Endfor
End
```

Figure 8. The pseudo-code standard explanation of the algorithm used to create every possible combination of four variables and comparing their sum to the farmer's suggested price.

```
       predicted value  Actual value
0         2.268250e+07      22705500
1         3.910894e+07      39103500
2         1.662231e+07      16617000
3         1.887231e+07      18866250
4         1.615735e+07      16173000
...                ...           ...
13717     8.810608e+06       8817000
13718     1.735875e+07      17349750
13719     1.721058e+07      17204250
13720     5.358912e+06       5354250
13721     2.066048e+07      20652750

[13722 rows x 2 columns]

performance on testing data 0.9999976682901893
performance on training data 0.9999976808680036
```

Figure 9. Construction performance system for the first approach.

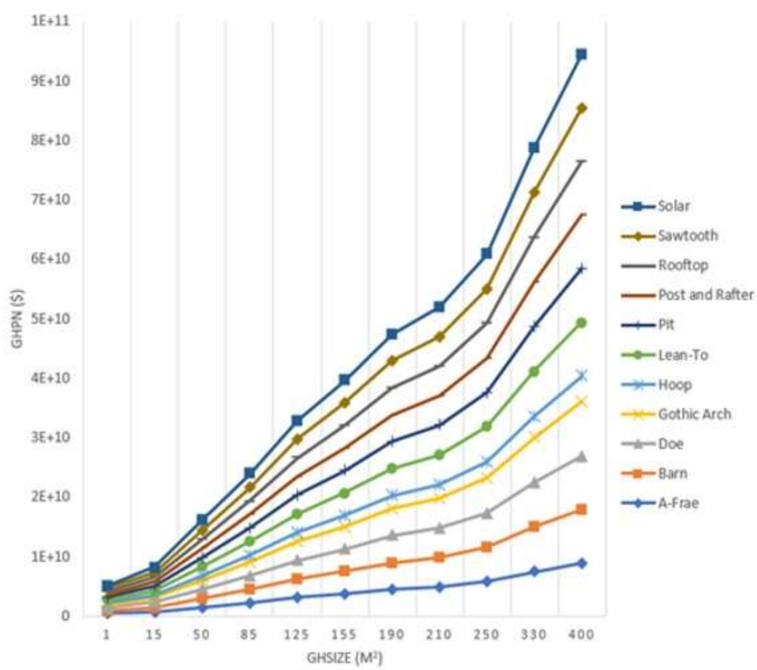

Figure 10. Construction of different greenhouse styles.

regression machine learning algorithms (Ridge regression, OLS model, Bayesian regression, Elastic Net regression, and Lasso regression), previously studied in another field (Rohimi *et al*., 2019; Mehta *et al.*, 2021). Moreover, the study of a decision tree ensued, with random forests also used to train and test the model. All the results appear in Table 3 and Figure 9, along with their respective predicted and actual values. Different greenhouses styles and designs, along with cost and each bar, showed a contrasting building feature (Figure 10).

The second approach was to estimate the predicted design based on the suggested price from the farming community. The same construction variables and controls are available as in the first one and have been used to advise and make the design more efficient. In past research, a study of the Naive solution in limited mathematical approaches transpired (Muñoz and Moguerza, 2005; Mairing, 2017; Al-Asadi *et al*., 2022); however, in these studies, engaging a Naive solution algorithm generated all possible construction variables and compared the sum with the suggested price. The second approach's output algorithms and the associated costs for the various system parameters are available in Figure 11. The relationship between the diverse attributes and the cost proves it a beneficial tool for system enhancements in the future (Table 4). The UML activity diagram illustrates the workflow for the price prediction and the design suggestion processes, highlighting a crucial difference between the two (Figure 12).

The proposed algorithms of this research had various scenarios experienced them for two main approaches, i.e., measuring the system's performance to predict the cost of greenhouse building, which is made by constructing and training the five different types of machine learning algorithms and predicting the cost of design using a Naive solution to generate all possible construction variables and compare the sum of them with the suggested price (Muñoz and Moguerza, 2005; Mairing, 2017).

Results of the simulation and comparison showed that the proposed greenhouse cost and design forecasting system had a high level of accuracy. Furthermore, it details the association between four main attributes and the cost, making it a handy tool for future augmentation. However, the correlation between various features and the price still needs improvement. Further research can proceed to include more attributes and a larger sample size to overcome such limitations. Additionally, incorporating qualitative data, such as, customer feedback, can provide a more comprehensive understanding of the factors influencing the total cost (Choab *et al*., 2021; Kondaveeti and Mathe, 2021). The multiple linear regression techniques combined with the Spearman correlation coefficient can further improve greenhouse cost forecasting (Cañadas *et al*., 2017; Alahudin *et al*., 2018; Mahmud, 2021).

CONCLUSIONS

Machine learning algorithms can improve the design of greenhouses, saving the growers time and money and improving their crop production. It may further encourage the farmers to better take decisions about the size and design of their greenhouses by using these algorithms with more efficient and profitable operations in the long run.

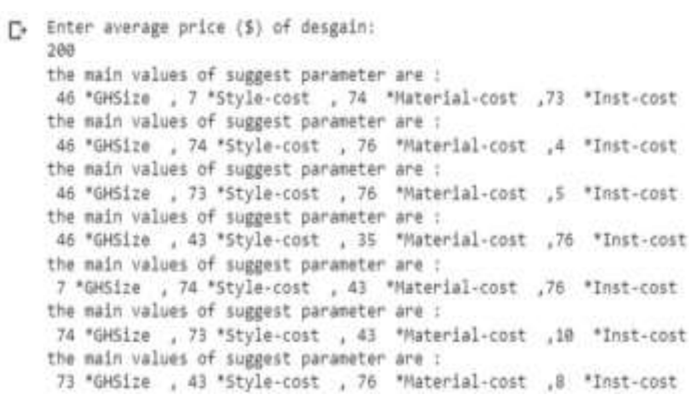

Figure 11. The second approach's output algorithms.

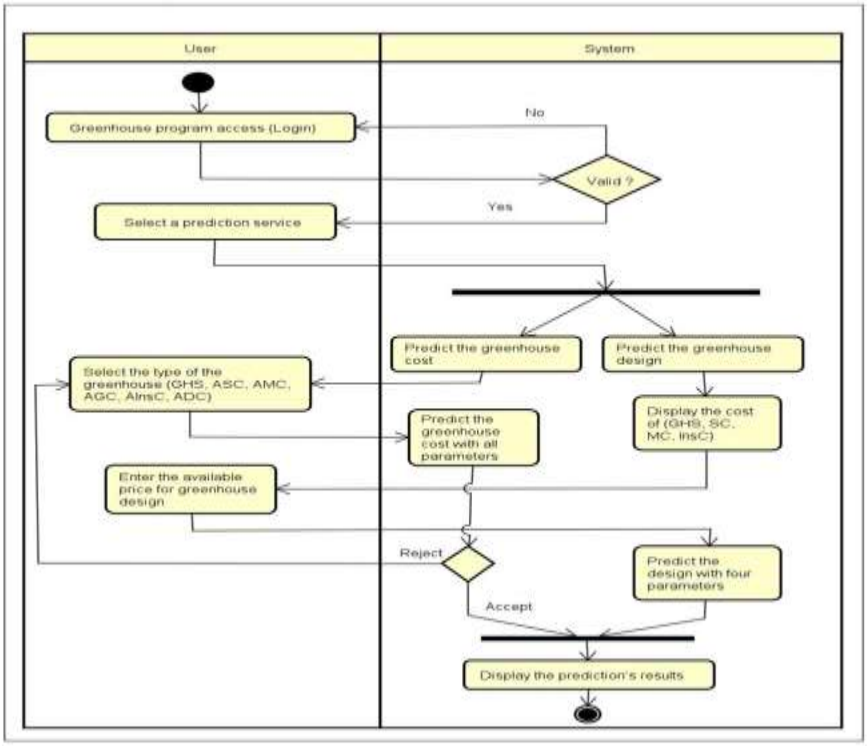

Figure 12. Activity flowchart for the proposed framework in UML format.

REFERENCES

Al-Asadi HH, Goga N, Ali HA, Popa RC, Oludele A (2022). Trends and challenges of sustainable agriculture in the Iraqi environment. *2022 IEEE International Conference on Blockchain, Smart Healthcare and Emerging Technologies (SmartBlock4Health)*. Bucharest, Romania. pp. 1-8. doi: 10.1109/ SmartBlock4Health56071.2022.10034651.

Alahudin M, Widarnati I, Sri-Suryaningsih NL (2018). Household scale of greenhouse design in Merauke. *J. Phys. Conf. Ser* 1025(1): 1-13.

Cañadas J, Sánchez-Molina JA, Rodríguez F, del-Águila IM (2017). Improving automatic climate control with decision support techniques to minimize disease effects in greenhouse tomatoes. *Inf. Process Agric.* 4(1): 50-63.

Choab N, Allouhi A, Maakoul AE, Kousksou T, Saadeddine S, Jamil A (2021). Effect of greenhouse design parameters on the heating and cooling requirement of greenhouses in Moroccan climatic conditions. *IEEE Access* 9: 2986-3003.

Kondaveeti HK, Mathe SE (2021). A systematic literature review on prototyping with Arduino: Applications, challenges, advantages, and limitations. *Computer Science Review*. Vol. 40. https://doi.org/10.1016/j.cosrev.2021.100364.

Mahmud S (2021). Opportunities and challenges of sustainable agricultural development in Iraq. *Int. J. Soc. Relev. Concern* 9(19): 12-24.

Mairing JP (2017). Thinking process of Naive problem solvers to solve mathematical problems. *Int. Edu. Studies* 10(1): 1-11.

Mehta CR, Chandel NS, Rajwade Y (2021). Smart farm mechanization for sustainable Indian agriculture. *Ama, Agric. Mechaniz. in Asia, Africa & Latin America*. 50: 99-105.

Muñoz A, Moguerza JM (2005). A Naive solution to the one-class problem and its extension to kernel methods. *Lecture notes in Computer Sci.* vol. 3773. *Springer*, Berlin, Heidelberg.

Rohimi R, Woaswi W, Awang R, Rizman ZI, Mohamed M (2019). Design and prototype development of automated greenhouse with Arduino and (IoT) application. *J. Adv. Sci*. 28: 437-446.