# Intelligent Decision Model to Predict and Manage the Food Security Status of Dry Broad Beans

Mohamed M. Reda Ali[1]
Faculty of Computers and Artificial Intelligence
Fayoum University
Fayoum, Egypt.

Maryam Hazman[2]
Climate Change Information Center, Renewable Energy, and Expert Systems Agriculture Research Center (ARC),
Giza, Egypt.

Mohamed H. Khafagy[3]
Faculty of Computers and Artificial Intelligence
Fayoum University
Fayoum, Egypt.

Mostafa Thabet[4]
Faculty of Computers and Artificial Intelligence
Fayoum University
Fayoum, Egypt.

**Abstract:- Dry Broad Beans (DBB) is the first strategic legume crop in Egypt and other developing countries. Also, it is considered one of the most popular Egyptian foods from the Pharaonic age to now. This study aims to develop an Intelligent Decision Model to Predict and Manage the Food Security Status of DBB (IDMPMFSSDBB). The proposed model utilizes Data Mining Classification Technique (DMCT) and its algorithms such as Random Tree (RT), Random Forest (RF), …, and J48 algorithms to classify and predict the Food Security Status of DBB (FSSDBB) in agriculture demographic regions in Egypt. It collects data features which are Food Security Markers for DBB (FSMDBB) from official statistical reports to build the Food Security of DBB Dataset (FSDBBD). It determines the patterns of DBB production and consumption to determine the annual Average Per Capita of DBB (APCDBB), and the Self-Sufficiency Ratio of DBB (SSRDBB) in the current and future times according to the proposed model. IDMPMFSSDBB supports decision-makers with informed decisions to meet the Egyptian population's needs, supports the food security situation for DBB, and fights grain instability prices, and crises in global trade markets. The accuracy of the classification process to predict FSSDBB was 98.41%, 97.88%, 97.35%, 97.35%, 96.3%, and 89.94% through Multilayer Perceptron CS (MLPCS / ANN), Simple Logistic (SL), RF, J48, RT, and Naïve Bayes (NB) algorithms respectively. It had respectively the following pairs of Mean Absolute Errors (MAE), and Root Mean Square Errors (RMSE): (0.024, 0.12), (0.049, 0.14), (0.042, 0.14), (0.027, 0.16), (0.037, 0.19), and (0.11, 0.28).**

***Keywords:-*** *Intelligent Decision Model to Predict and Manage the Food Security Status of Dry Broad Beans (IDMPMFSSDBB); Data Mining Classification Techniques (DMCT); Food Security Status of Dry Broad Beans (FSSDBB); Self–Sufficiency Ratio of Dry Broad Beans (SSRDBB).*

## I. INTRODUCTION

In 2022, Acute Food Insecurity (AFI) affected 258 million individuals in 58 nations around the world [1-3], based on the unstable grains pricing conditions in the international trade markets, high shipping and energy costs, and other worldwide crises such as the Russian-Ukrainian War, natural disasters, earthquakes, COVID-19, or other global (regional) factors [1-7]. In Africa, 33 nations require external food assistance, while 9 countries in Asia, 2 nations in Latin America, and Ukraine in Europe have comparable dietary difficulties [4].

The inability to grow and provide strategic crops for sufficient healthy food for people in developing countries will expose the Sustainable Development Goals (SDGs) that approved by the United Nations to fail. This is a result of the state of hunger and poverty caused by food insecurity for essential food for a healthy life in these countries [1-8]. The Integrated Food Security Phase Classification (IPC) had the following classification phases [1, 3]:

- *Phase 1: Acceptable Food Security situation.*
- *Phase 2: Alert (Stressed) food insecurity situation.*
- *Phase 3: Crisis (Serious) food insecurity situation.*
- *Phase 4: Emergency (Critical) food insecurity situation.*
- *Phase 5: Catastrophe food insecurity situation.*

DBB, Faba Beans, or Fava Beans (Vicia faba) is considered one of the most important foods in Egypt. Also, it has a first preference as a main food on Egyptian breakfast tables [9-11]. Wheat, Maize, and DBB are the strategic crops in Egypt. Where in 2021, Egypt paid 8 Billion USD to import Wheat, Maize (Corn), and soybeans from the global grain markets to meet Egyptian population needs from these crops [12]

Egypt suffers from a food gap to meet its needs from fava / faba beans (which is DBB) over the past decade, where the Self-Sufficiency Ratio of DBB (SSRDBB) was 38.84%, 27.82%, 33.84%, 31%, 20.9%, 30.7%, 12.4%, 10.5%, 17.3%, and 21.14% from 2012 to 2021 respectively based on the

ISSN No:-2456-2165

domestic DBB production, imports of DBB, and Domestic Supply Quantity of DBB (DSQDBB). The Egyptian DBB production in 2021 reached 170 Thousand tons from growing 117 thousand feddans by Fully Broad Beans /DBB (i.e. 1 feddan = 0.42 hectare) [9, 13-18].

The study aims to develop an intelligent decision model to predict and manage the FSSDBB in demographic agriculture regions in Egypt by utilizing Data Mining Classification Technique (DMCT) and its algorithms to support decision-makers with informed decisions to manage the FSSDBB and close DBB food insecurity gap and its SSRDBB in Egypt. The study will try to answer the following questions:

- *Do we need to achieve food security and self-sufficiency in strategic crops?*
- *Can Food Security data be collected for DBB?*
- *What are the agriculture demographic patterns of DBB production and consumption in Egypt?*
- *What is the methodology(s), technique(s), and algorithm(s) suitable to develop the proposed model for predict FSSDBB?*
- *How to solve the problem of DBB insecurity?*
- *What is the architecture and design for the proposed model to predict and manage FSSDBB?*
- *What are the factors that affect the process of predicting the food security status of the strategic crop(s)?*
- *How does the proposed model improve the SSRDBB?*
- *What are the impacts of the proposed model?*

This paper is organized into the following five sections: the first section for research introductory, and the second section to explore backgrounds and literature reviews. Section three presents the research materials and methods, and research results and discussion will be explored in section four. Finally, section five includes the conclusions and perspectives.

## II. BACKGROUNDS AND LITERATURE REVIEWS

Badjona et al. (2023), considered Faba beans (DBB) a useful natural source for traditional nutrition and support many biological activities such as antihypertensive, anticarcinogenic, antimicrobial, hypocholesterol, antithrombotic, mineral needs, and growth-promoting properties as shown in figure 1 [11].

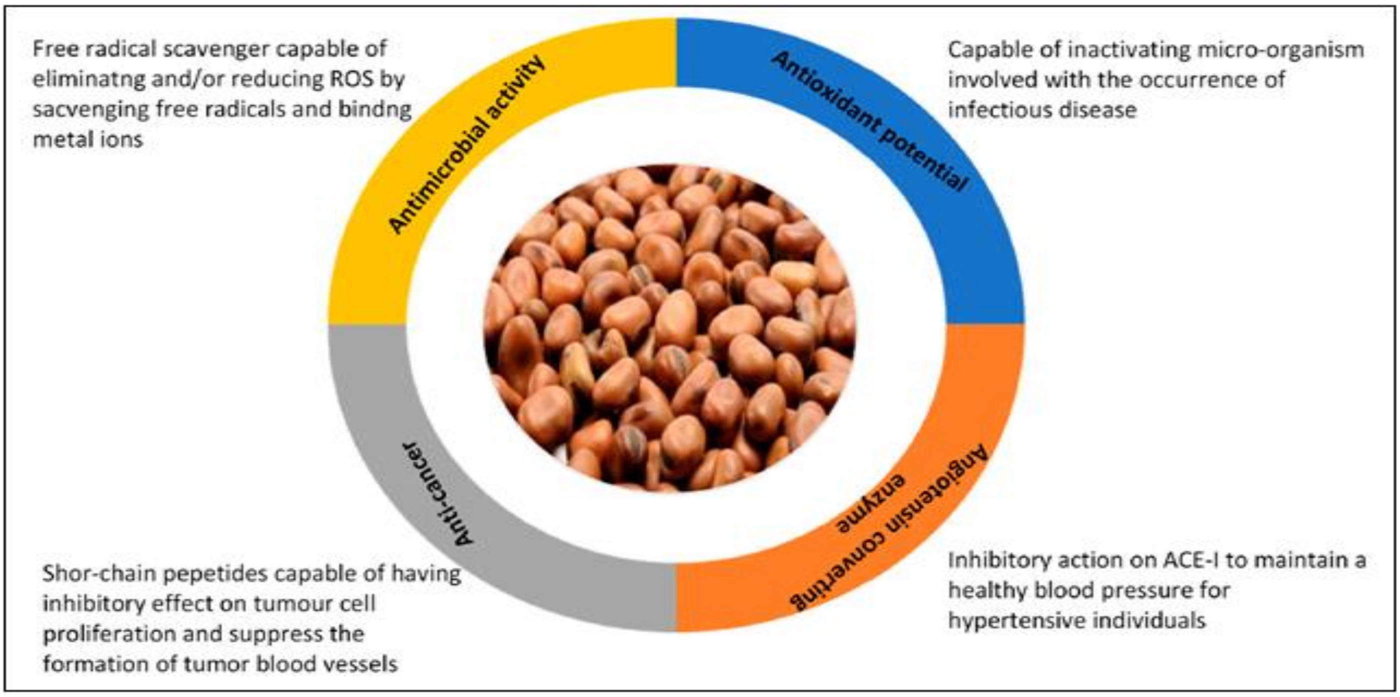


Fig 1 The Healthy Benefits of Faba Beans on Biological Activities [11].

Data Mining is a branch of Artificial Intelligence (AI) techniques. It has several techniques such as Classification, Clustering, Summarization, etc. [19-20]. Data mining or Machine Learning (ML) had algorithms to discover various models, patterns, summarizations, and useful information from business data (database(s) , repository(ies), dataset(s)) to support decision-makers with informed decisions to solve problems [21-22].

M. Reda Ali et al. (2023), utilized Random Tree (RT) algorithms as a data mining classification technique to predict the Food Security Status of Wheat (FSSW) in Egypt based on the features of demographic Wheat production and consumption [6]. Padma and Sinha (2023), predicted the crop yield prediction by using Decision Tree (DT), Random Forest (RF), MLR as Machine Learning Algorithms (MLA) based on the following parameters climate temperature, and rainfall, pesticides, crop type, and field area [23].

ISSN No:-2456-2165

Ed-Daoudi et al. (2023), used Decision Tree (DT), Random Forest (RF), and Neural network (FFANN) as Machine Learning (ML) algorithms to predict crop yields for Wheat, Apple, Olives, Dates, and Almonds in Morocco [24]. Dash et al. (2021), utilized data mining classification technique through SVM, ID3, C4.5, and CART algorithms to predict crop yields for Rice, Wheat, and Sugarcane based on climatic parameters (rain, humidity, temperature, and sunshine) and soil macro factors like (Ph.) to select a suitable crop for cultivation [25].

Vogiety (2020) used a random forest algorithm to predict the crop yield production before cultivation by using data mining classification techniques based on climate change parameters to assist ranchers with crop production [26]. Akhand et al. (2018), utilized satellite remote sensing techniques (VCI, TCI, AVHRR) and Artificial Neural Network (ANN) to predict Wheat yield [27].

## III. RESEARCH MATERIALS AND METHODS

This paper introduces an Intelligent Decision Model to Predict and Manage the Food Security Status of DBB (IDMPMFSSDBB). The proposed model has the following five phases as shown in figure 2.

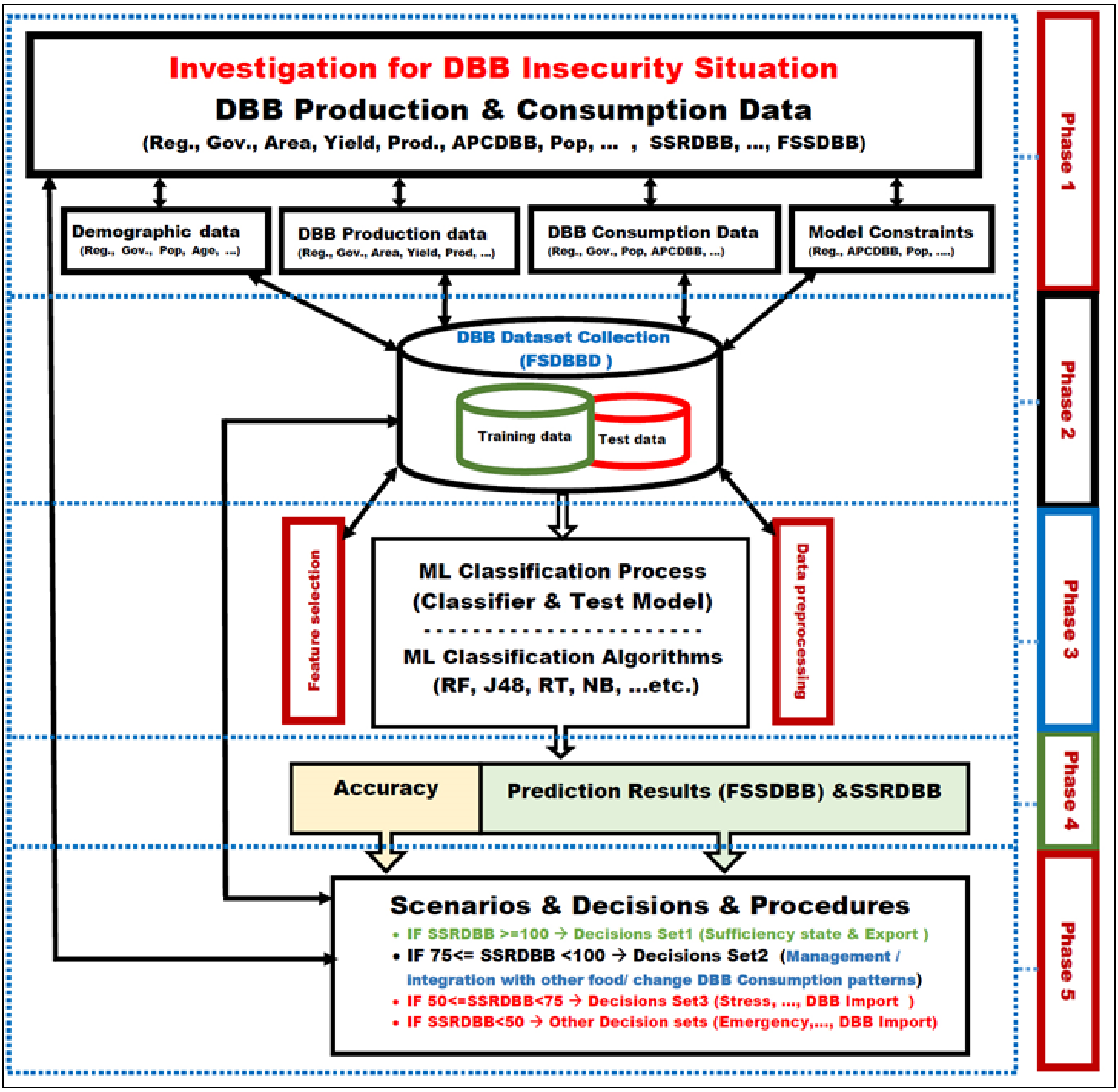

Fig 2 The Architecture of the Proposed Model to Predict and Manage the FSSDBB in Egypt

- Phase one to investigate the DBB insecurity situation in Egypt and assume the research assumptions.
- Phase two to collect the related data for agriculture demographic DBB production and consumption in Egyptian regions and its governorates from 2015 to 2021 to build the Food Security of DBB Dataset (FSDBBD).
- Phase three is to perform a data mining classification process to predict FSSDBB through data mining classification algorithms such as RF, RT, ANN, etc.
- Phase four is to explore prediction results and its evaluations.
- Phase five is to explore research recommendations and decisions to manage DBB production and SSRDBB in Egypt according to DBB dataset features or FSMDBB.

➢ *DBB Insecurity Investigation*

The Broad Beans crop had three types as the following: Fully Mature Single Broad Beans, Fully Mature Intercropped Broad Beans, and Green Broad Beans (GBB). Where Dry Broad Beans (DBB) are produced from more than 97%-98% of Fully Mature Single Broad Beans [15 - 16]. The agriculture area allocated for DBB cultivation was more than 90% of the total area for all types of DBB, and the remaining area was allocated to grown GBB. Table 1 explores the food balance sheet of DBB in Egypt from 2007 to 2021, and figure 3 illustrates the Domestic Production of DBB (DPDBB), imports of DBB (IDBB), and Domestic Supply Quantity of DBB (DSQDBB) [13 -18].

Table 1 The Food Balance Sheet for DBB in Egypt From 2007 to 2021

| **Year** | **ADBB** | **DPDBB** | **IDBB** | **DSQDBB** | **Pop.** | **APCDBB** | **SSRDBB** |
|---|---|---|---|---|---|---|---|
| 2007 | 212 | 305 | 301 | 591 | 74828 | 7.9 | 51.60% |
| 2008 | 170.1 | 244 | 655 | 847 | 76651 | 11.05 | 28.80% |
| 2009 | 206 | 298 | 146 | 425 | 78522 | 5.41 | 70.12% |
| 2010 | 183.7 | 234 | 179 | 395 | 80443 | 4.91 | 59.24% |
| 2011 | 131.4 | 175 | 297 | 469 | 82410 | 5.69 | 37.3% |
| 2012 | 98 | 141 | 237 | 363 | 84418 | 4.3 | 38.84% |
| 2013 | 105 | 158 | 425 | 568 | 86460 | 6.57 | 27.82% |
| 2014 | 89.7 | 134 | 280 | 396 | 88530 | 4.47 | 33.84% |
| 2015 | 81.93 | 120 | 279 | 387 | 90624 | 4.27 | 31% |
| 2016 | 83.4 | 119 | 484 | 569 | 92737 | 6.14 | 20.91% |
| 2017 | 121 | 170 | 438 | 554 | 95203 | 5.82 | 30.7% |
| 2018 | 82.18 | 116 | 850 | 933 | 97147 | 9.6 | 12.43% |
| 2019 | 69.81 | 101 | 892 | 964 | 98902 | 9.75 | 10.48% |
| 2020 | 89.14 | 125 | 618 | 723 | 100617 | 7.18 | 17.29% |
| 2021 | 117.3 | 170 | 669 | 804 | 102061 | 7.88 | 21.14% |

[a] ADBB is the DBB cultivation area in 1000 feddans, DPDBB is the Domestic production of DBB in 1000-Tons; IDBB is the Imports quantity of DBB in 1000-Tons; Pop. Is the Population in 1000 Citizens; DSWDBB is the Domestic Supply Quantity of DBB in 1000 Tons [13 - 18];

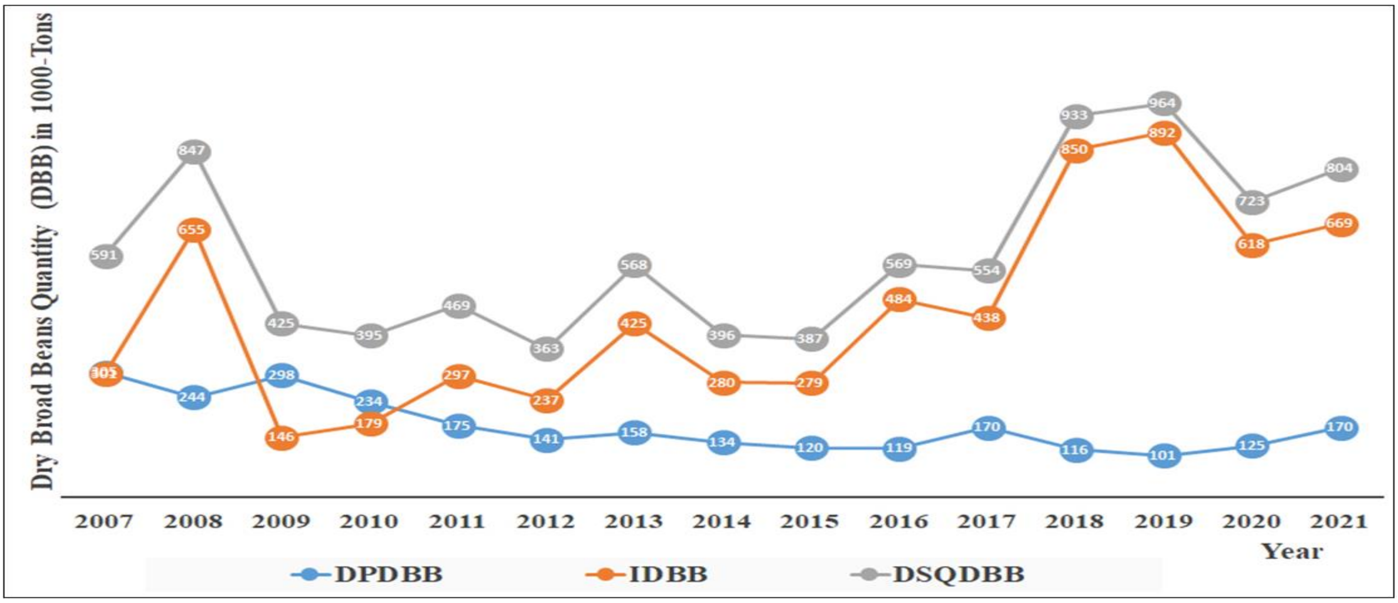


Fig 3 The Food Balance Sheet for DBB from 2007 to 2021 in Egypt.

Egypt is reclaiming about 2.5 million hectares to increase the agricultural cultivation areas according to the Egyptian Sustainable Development Goals 2030 (ESDGs) to close the food security gaps for strategic crops in the following four agriculture regions [15, 16, 28, 29]:

- Lower Egypt (R1) that involves 13 governorates (Behera, Suez, Alexandria, Cairo, Dakahlia, Damietta, Gharbia, Ismailia, Kafr El Sheikh, Monufia, Port Said, Qalyobia, and Sharkia).
- Middle Egypt Region (R2) that involves 4 governorates named (Giza, Beni Suef, Faiyum, and Minya).
- Upper Egypt region (R3) that involves 5 governorates (Asyut, Qena, Luxor, Suhag, and Aswan).
- Outside the Egyptian valley region (R4) that involves 5 governorates (Matruh, North Sinai, South Sinai, Red Sea, and New Valley).

The cultivation of DBB in R3 wasn't useful, because it produced a limited average yield that reached less than one ton of DBB from one DBB feddan in Aswan that was grown 5000 Feddan of DBB. Also, the yield of one feddan for another 5000 feddans grown DBB in Assuit and Suhag, was approximately 1.2 tons / feddan.

- *The Research Assumes the following Assumptions to Predict FSSDBB in Egypt:*

✓ The Population Growth Rate (PGR) for Egyptian population was about 1.5 % from 2020 to 2023 [30-31].
✓ APCDBB = 4.5 Kg. / Citizen / year (is the average of four minimum APCDBB in table 1 for years 2010, 2012, 2014, and 2015, APCDBB = (4.91+4.3+4.47+4.27)/4= 4.5 Kg [13 -17].
✓ The number of people who consumed DBB equaled the real population volume. Where the number of consumers of citizens without infants and the number of residents and visitors is approximately equal to the total number of the population [6].
✓ Used modern agriculture methods, and techniques, and applied agriculture practices and recommendations issued by the Egyptian Ministry of Agriculture and Land Reclamation (MLAR), Agriculture Research Center, and its agriculture institutes and stations in Egypt [6, 9, 18, 28-29].
✓ The area of DBB in Behera governorate = the area of Wheat in Behera and Noubaria city [6].
✓ Neglect other factors.

➢ *Data Collection for Food Security of DBB*

- *Data Resources of FSDBBD*

The Food Security of DBB data collected from several statistical resources issued by the following organizations to build the Food Secuirty of DBB Dataset (FSDBBD):

✓ Central Agency for Public Mobilization and Statistics in Egypt (CAPMAS) [13, 14, 15, 30, 31]
✓ Economic Affair Sector (EAS) in the Ministry of Agriculture and Land Reclamation (MALR) [10, 16, 17].
✓ Ministry of Agriculture and Land Reclamation (MLAR) Strategy for Sustainable Agricultural Development in Egypt 2030, and its recommendations for faba beans / Broad beans cultivation [9, 18, 29, 30].

- *Sample of FSDBBD*

Table 2 represents a sample of the Food Security of DBB Dataset (FSDBBD) that involved features or FSM for DBB production and consumption in demographic agriculture regions and its governorates in Egypt from 2015 to 2021. The FSDBBD file is a comma-separated values (FSDBBD.CSV) format. It has the following attributes/ FSM/ features:

✓ Year: is a prediction year for the food security status of agriculture crop(s)
✓ Reg: An agriculture Region in Egypt that involve R1, R2, R3, and R4.
✓ Gov: The Governorate (27 governorates in 4 regions).
✓ ADBB: Area of DBB (in feddan)
✓ Yield: The productivity unit from grown one DBB feddan (in tons)
✓ DPDBB: Domestic Production of DBB (in tons)
✓ Pop.: The Population (in 1000 Citizens)
✓ APCDBB: Average Per Capita of DBB for each Citizen / Year ( in Kg. / Citizen /Year)
✓ Req. DBB: The quantity of Required DBB (in tons) (= APCDBB x Pop = 4.5 x Pop.)
✓ FSSDBB: The Food Security Status of DBB (FSSDBB = Yes if DPDBB>= Req. DBB, Otherwise = No)
✓ SSRDBB:The Self-Sufficiency Ratio of DBB (= DPDBB / Req. DBB %)

Table 2 Sample of FSDBBD in Egypt from 2015 to 2021

| Year | Gov. | Reg | ABB | Yield | DPDBB | Pop. | Req. DBB | FSSDBB |
|---|---|---|---|---|---|---|---|---|
| 2015 | Behera | R1 | 34120 | 1.65 | 56454 | 6002 | 27009 | Yes |
| … | … | … | … | … | … | … | … | … |
| 2015 | Sharkia | R1 | 7382 | 1.47 | 10882 | 6680 | 30060 | No |
| … | … | … | … | … | … | … | … | … |
| 2016 | Aswan | R3 | 1916 | 1.06 | 2040 | 1511 | 6799.5 | No |
| … | … | … | … | … | … | … | … | … |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 2020 | Fayoum | R2 | 1055 | 1.04 | 1101 | 3858 | 17361 | No |
| … | … | … | … | … | … | … | … | … |
| 2021 | Suhag | R3 | 1967 | 1.54 | 3032 | 5486 | 24687 | No |
| … | … | … | … | … | … | … | … | … |
| 2021 | New Valley | R4 | 4430 | 1.34 | 5953 | 259 | 1165.5 | Yes |
| … | … | … | … | … | … | … | … | … |

➢ *Data Mining Classification Process*

Firstly, upload the FSDBBD file in the Weka tool [32], to visualize it in 2-D diagrams to select the classification process features as shown in figure 4.

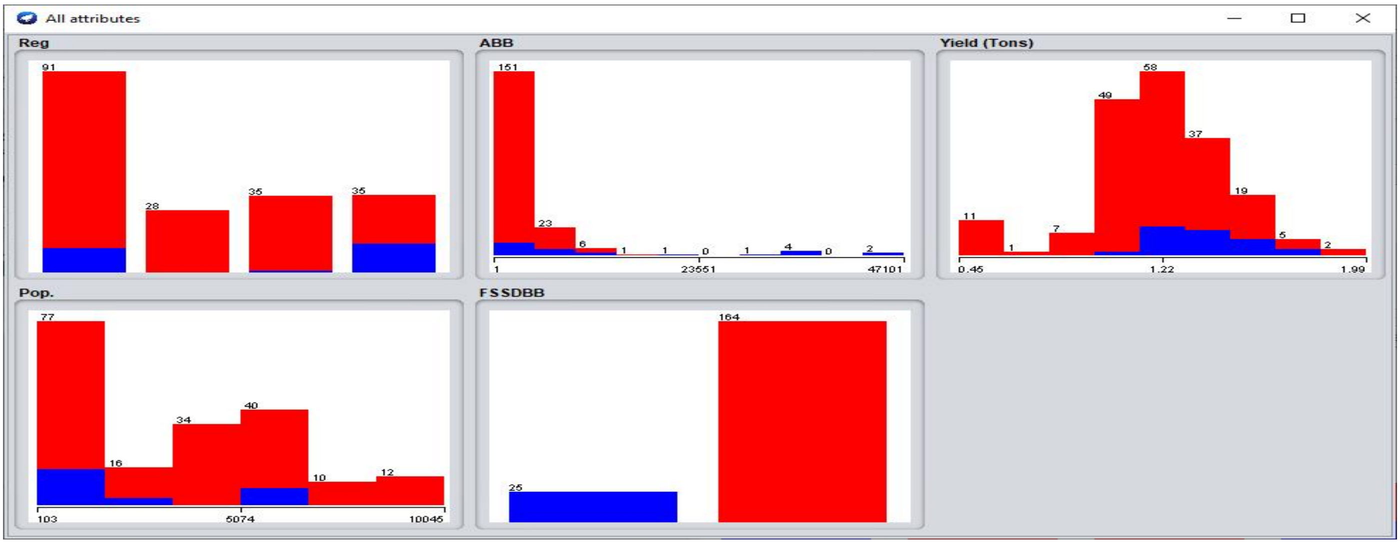


Fig 4 The 2- Dimensions diagram for features of FSDBBD

Then spilt FSDBBD by 10-fold cross validation method to spilt FSDBBD into two datasets for learning classification model from leaning dataset that represent (70%) from FSDBBD, and the remaining 30% to test classification model validation as shown in figure 5.

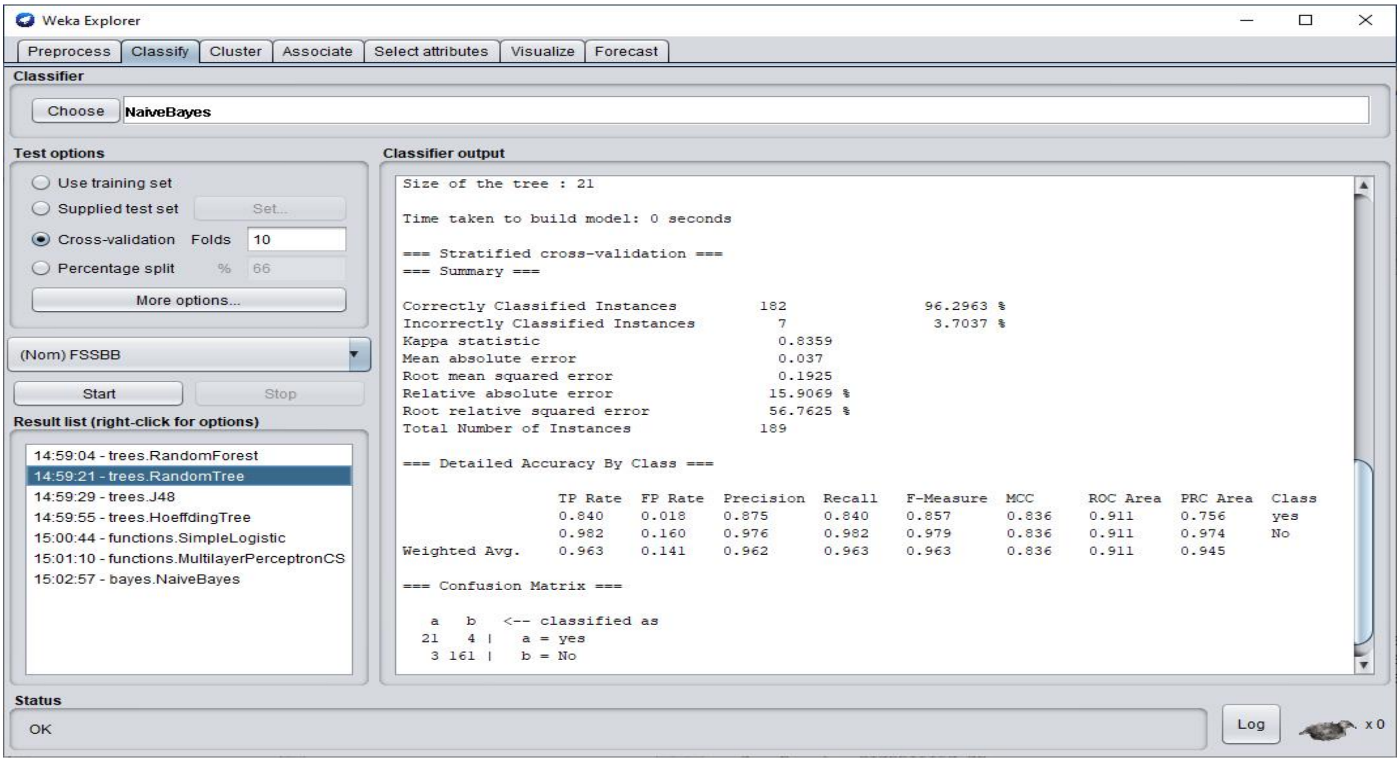


Fig 5 The Splitting Methods for FSDBBD

The classification process will predict the FSSDBB for each instance or record in FSDBBD through Random Forest (RF), Random Tree (RT), Neural Network (ANN), Simple logistic, and Naïve Bayes (NB) algorithms in Weka tool [32]. Figure 6 illustrates the decision tree diagram which is generated from the Random Tree (RT) algorithm.

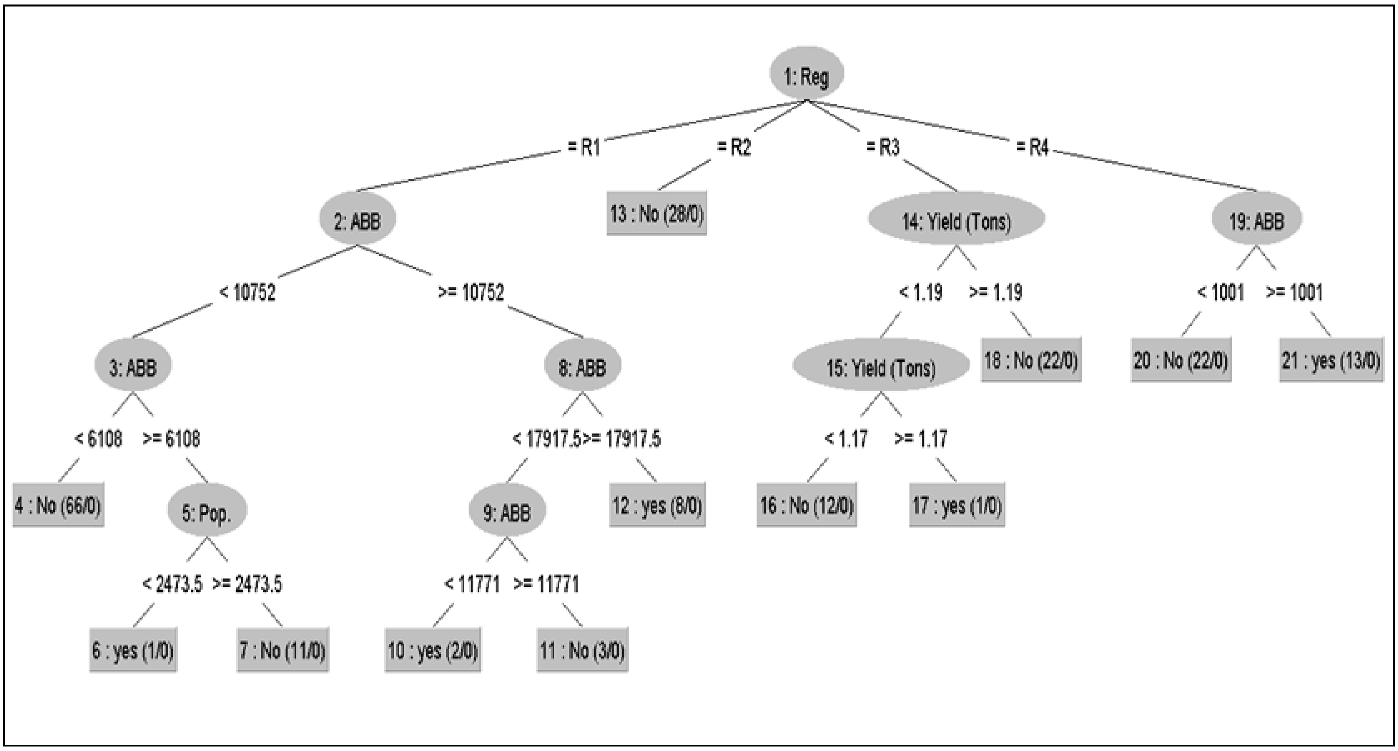

Fig 6 RT Diagram to Predict FSSDBB for FSDBBD Instances

Experts / decision makers can extract the prediction equations from figure 6 according to the classification features in the previous diagram to predict FSSDBB for unknown instances based on equations from 1 to 10.

- If Reg = R1, ABB>= 17917→FSSDBB= Yes (1)
- If Reg = R1, 10752 <=ABB < 11771→ FSSDBB =Yes (2)
- If Reg = R1, 6108<=ABB<10752, Pop <2473→ FSSDBB =Yes (3)
- If Reg = R2→ FSSDBB= No (4)
- If Reg = R3, Yield < 1.17→ FSSDBB= No (5)
- If Reg = R3, Yield >= 1.19→ FSSDBB= No (6)
- If Reg = R3, 1.17<=Yield<1.19→ FSSDBB= Yes (7)
- If Reg = R4, ABB>= 1001→ FSSDBB= Yes (8)
- If Reg = R4, ABB <1001→ FSSDBB= No (9 )
- Else FSSDBB= No (10)

➢ *Results of Data Mining Classification Process*

FSSDBBD had 189 instances of DBB production from 2015 to 2021 in Egyptian demographic agriculture regions and its governorates. For evaluating the classification process results, confusion matrix recognition had been computed [16-18]. The classification process had the following retrieval information based on figure 3 and equations 1-10 [6, 20 - 21]:

- Tp : is a number of instances that classified as true Positive (correctly predicts) and reserved to Positive class.
- Fp : is a number of instances that classified false Positive but realism fits into the Negative class
- FN : is a number of instances that classified false Negative but realism fits into the Positive class
- TN: is a number of instances that classified as true Negative (correctly predicts) and reserved to Negative class.
- Accuracy: is the all correct predictions instances divided by the total number of retrieval instances
- **Accuracy = ((Tp + TN) / (Tp+TN+Fp+FN)) x 100 % (11)**
- Recall: is the number of true positive predictions divided by divided by the total number of true positives and false negative.
- **Recall = Tp / (Tp + FN) (12)**
- Precision: is the number of true (correct) positive predictions divided by the total number of positive.
- **Precision = Tp / (Tp + Fp) (13)**
- F1-Score: measure the model prediction accuracy through the measurements of precision and recall.
- **F1- Score = 2 x (Precision x Recall)/ (Precision + Recall) (14)**

ISSN No:-2456-2165

➢ *Recommendations and Decisions*

The research recommendation depends on the features of FSDBBD to increase crop production to improve SSRDBB as the following Recommendations:

- Increase the allocated area for growing DBB in New agriculture investment projects to be 400 thousand feddans (i.e. Egypt's Future and Saini Development projects)
- Increase DBB Yield to be 1.7 to 1.8 tons / feddans
- Create new investment projects
- Clustering the smallholder lands in sectors
- Cultivate DBB in large Sector in R1, north areas in R4
- More Jobs and integrated communities
- Decrease PGR
- Rationalize the consumption and waste patterns for DBB to decrease APCDBB
- Use modern agriculture methods and techniques
- Apply the agricultural practices and recommendations through different cultivation and post-harvest, industrial stages for DBB.
- Find alternative food or crops to integrate with DBB
- Use modern Sustainable Energy (Solar / Wind)

## IV. RESEARCH RESULTS AND DISCUSSION

### A. *Results Evaluation*

Table 3 presents confusion matrix recognition functions for results of classification algorithms to predict FSSDBB for FSDBBD instances by using data mining classification algorithms such as Random Forest (RF), Random Tree (RT), Simple Logistic (SL), Multilayer Perceptron CS (MLPCS / ANN), Naïve Bayes (NB), and C4.5 (J48) algorithms.

Table 3 Results of Classification Algorithms to Predict FSSDBB

| **Items (Function)** | **DM classification (ML) Algorithms** | | | | | |
|---|---|---|---|---|---|---|
| | ***RF*** | ***RT*** | ***SL*** | ***MLPCS*** | ***NB*** | ***J48*** |
| Tp | 21 | 21 | 22 | 23 | 10 | 22 |
| Fp | 4 | 4 | 3 | 2 | 15 | 3 |
| FN | 1 | 3 | 1 | 1 | 4 | 2 |
| TN | 163 | 161 | 163 | 163 | 160 | 162 |
| Total Inst. | 189 | 189 | 189 | 189 | 189 | 189 |
| Precision | 0.955 | 0.875 | 0.957 | 0.958 | 0.714 | 0.917 |
| Recall | 0.84 | 0.84 | 0.88 | 0.92 | 0.4 | 0.88 |
| Accuracy | 97.3% | 96.%3 | 97.9% | 98.4% | 89.9% | 97.3% |
| F1 | 0894 | 0.857 | 0.917 | 0.939 | 0.51 | 0.898 |
| RMSE | 0.14 | 0.19 | 0.14 | 0.12 | 0.28 | 0.16 |
| MAE | 0.042 | 0.037 | 0.049 | 0.024 | 0.11 | 0.027 |

### B. *The Self Sufficiencey Ratio of DBB (SSRDBB)*

Table 4 presents simulation scenarios for SSRDBB in 2021 and 2030 according to the current and proposed situations in 2021. Also, it presents the future situations for SSRDBB in 2030 according to MLAR (SDGs), and the proposed model and research assumptions to predict FSSDBB in Egypt.

- ABB Area: The Area of DBB – in 1000 feddans
- DBB Yield: The average yield of DBB from one feddan grown DBB - in tons,
- DBB Production – 1000 tons (DBB Area x DBB yield),
- DSQDBB: The Domestic Supply Quantity of DBB, DSQDBB = (Area DBB x Yield) in 1000 tons
- Req. DBB= The Required quantity of DBB (Req. DBB) Req. DBB = APCDBB x Pop. in 1000 tons,
- Pop: The Population - in million Citizens.
- APCDBB: The Average Per Capita of DBB for each Citizen / Year – in Kg.
- SSRDBB: The Self-Sufficiency Ratio of DBB, SSRDBB = (DBB Production / DSQSDBB) x100% for real situation in 2021 and MALR situation in 2030, or, SSRDBB= (DBB Production / Req. DBB) x100 % for proposed situations in 2021and 2030.

Table 4. Situations of SSRDBB in Egypt in 2021 and 2030

| **Items** | **Real DBB Situation in 2021** | **Proposed DBB Situation in 2021** | **MALR / SDGs Situation in 2030** | **Proposed DBB Situation in 2030** |
|---|---|---|---|---|
| Year | 2021 | 2021 | 2030 | 2030 |
| BB Area | 117.3 | 117.3 | 350 | 400 |
| DBB Yield | 1.45 | 1.45 | 1.7 | 1.7 |
| DBB Production | 170 | 170 | 595 | 680 |
| DSQSDBB / Req. DBB | 804 | 459.27 | 688 | 525 |
| Population | 102.061 | 102.061 | 116.67 | 116.67 |
| APCDBB (Kg/Citizen) | 7.88 | 4.5 Kg. | 5.9 | 4.5 |
| SSRDBB | 170/804 = 21.14% | 170/459.3 =37% | 595/688= 86.5% | 680/525 =129.52% |

*C. Research Discussion*

The study recommends allocating 300,000 feddans for growing faba beans (DBB) in newly reclaimed areas in agriculture investment projects such as "Future Egypt's Project" and "Sinai Development Project". The National agricultural investment projects had the best cultivation lands for growing faba beans in agricultural regions R1, R2, and R4. Where DBB yield was reached 1.5- 1.7 tons/ feddans in these agriculture regions and its governorates such as Matruh, Damietta, Sharkia, and Behera (in Noubaria City) Alexandria, and Dakahlia.

DBB cultivated in a small cultivation area in R3. There were 5000 feddans grown faba beans with an average yield reached (0.6 -1 tons/ feddan) from one DBB feddan in Aswan. Also, there were about 5000 feddans grown faba bean in Assuit and Suhag with an average yield reached 1.2 tons/ feddan from one DBB feddan. So that, DBB cultivation was not recommended in R3. Thus, we will remove equations 5-7, to remove DBB production in R3. Also, we can remove equation 4 for Region 2 and substitute it by equation 10. Equations 15 - 20 represent classification and prediction processes for FSSDBB in Egypt to classify and predict FSSDBB for unknown instances in FSDBBD.

- If Reg = R1, ABB>= 17917→FSSDBB= Yes (15)
- If Reg = R1, 10752 <=ABB < 11771→ FSSDBB =Yes (16)
- If Reg = R1, 6108<=ABB<10752, Pop <2473→ FSSDBB =Yes(17)
- If Reg = R4, ABB>= 1001→ FSSDBB= Yes (18)
- If Reg = R4, ABB <1001→ FSSDBB= No (19 )
- Else FSSDBB= No (20)

*D. Research Impacts*

The impacts of IDMPMFSSDBB are summarized in the following points:

- The proposed model presents a methodology based on a Data mining classification technique to predict FSSDBB according to crop production and consumption features in demographic agriculture regions.
- Presented intelligent decision model architecture to predict and manage FSSDBB in Egypt and other development countries.
- Determined factors that affect the proposed model.
- Determined the patterns of DBB production and consumption in Egypt.
- Determined factors to manage and improve FSSDBB and SSRDBB according to Population Growth Rate (PGR), DBB production and consumption patterns.
- Supported decision makers in food security and agriculture with domains with informed decision and recommendations to select an appropriate alternative and insert roles and procedures to manage FSSDBB to achieve SDGs.

## V. CONCULSIONS AND PRESPECTIVES

This study presented IDMPMFSSDBB to predict the food security status of DBB by using Machine Learning classification algorithms such as Random Forest (RF), Random Tree, Naïve Bayes (NB)…, ANN, algorithms. It is recommended to add 300 thousand feddans to cultivate DBB.

The study performed comparative studies for the prediction results of data mining classification algorithms for the FSSDBB in Egypt from 2015 to 2021. Also, it determines SSRDBB in current and future situation according to the research assumptions. In 2021 the SSRDBB reached 37% compared to 21.14% in reality, in 2030 the SSRDBB will reach 86.5% according to MLAR SDGs, and will reach 129.52% according to the research assumptions.

In the future, we intend to integrate another machine learning techniques and algorithms to predict the food security status for other crops and commodities to decision makers and experts with informed decisions at the right times.

## REFERENCES

[1] GRFC, "Global Report on Food Crises (GRFC) 2023", World Food Programme (WFP), Food Security Information Network (FSIN) and Global Network Against Food Crises. GRFC 2023. Italy, 2023, https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2023-brief-EN.pdf

[2] FAO (a), "The state of food security and nutrition in the world 2023", Food and Agriculture Organization of the United Nations (FAO), Italy, 2023, https://www.fao.org/3/cc3017en/cc3017en.pdf

[3] IPC, "Integrated Food Security Phase Classification (IPC)", IPC, 2023, https://www.ipcinfo.org/

[4] FAO (b), "Crop prospects and food situation", Vol. 2, Food and Agriculture Organization of the United Nations (FAO), Italy, 2023, https://www.fao.org/3/cc6806en/cc6806en.pdf

[5] S. Arafa, H. Hassan, S. Shaltout, H. Shaddad, I. Zakhary, "A reference study of the repercussions of global crises on agriculture and food: The two cases of the Corona virus (COVID pandemic) and the Russian-Ukrainian war crisis", Economic Affairs Sector (EAS), Ministry of Agriculture and Land Reclamation (MALR), Egypt, 2023, http://www.arc.sci.eg/NARIMS_upload/NARIMSdocs//836397/AERI836397.pdf

[6] M. M. Reda Ali, M. Hazman, M. H, Khafagy, M. Thabet ," Utilization of data mining classification technique to predict the food security status of Wheat", icSoftComp 2022, India, CCIS1788 , pp 432-445, Decmber 2022 [ CCIS1788, 2023. Springer Nature Switzerland AG]

[7] T. Mamulaidze, " Food Security and the Importance of Big Data", International Journal of Innovative Science and Research Technology (IJISRT), Vol.(8.5) , PP 3272-3278, IJISRT, 2023.

[8] SDGs 2030, "The Seventeen Sustainable Development Goals by Untitled Nations", https://sdgs.un.org/goals

[9] A. Khalil, "Broad beans area in Egypt in 2021", Youm7 News, 10 February 2021, https://www.youm7.com/Article/NewsPrint/5198597

[10] H. El-Sayed, H. Abdul-Latif, H. Al-Zanfali, R. Farag, "Economic analysis of broad beans production in 2021", Economic Affairs Sector (EAS), Ministry of Agriculture and Land Reclamation, Egypt, 2021.

[11] A. Badjona, R. Bradshaw, C. Millman, M. Howarth, B. Dubey, "Faba Bean Processing: Thermal and Non-Thermal Processing on Chemical, Antinutritional Factors, and Pharmacological Properties", *Molecules*, vol 28(5431), pp 1-28, MDPI, 2023, https://doi.org/10.3390/molecules28145431

[12] B. Al-Ghannam, "The cost of Egypt's imports of wheat, Maize, and Soybeans in 2021", 7 Youm News, 21 May 2022, https://www.youm7.com/Article/NewsPrint/5770033

[13] CAPMAS (a), "Annual bulletin of the movement production and foreign trade and available for consumption of agricultural commodities in 2021", and other issues, CAPMAS, Egypt, 2023.

[14] CAPMAS (b), "Statistical yearbook 2022", and other issues. Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt, 2022.

[15] CAMPAS (c), "Annual bulletin of statistical crop area and plant Production in 2021", and previous issues., Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt, 2023.

[16] EAS (a), "Annual bulletin of the agricultural statistical for agriculture crops in 2021", Economic Affairs Sector (EAS), MALR, Egypt, 2023.

[17] EAS (b), "Annual bulletin of the Food Balance Sheet in 2021", and other issues. Economic Affairs Sector (EAS), MALR, Egypt , 2023. https://www.agri.gov.eg/uploads/topics/16819017944659.pdf

[18] A. Azmy, "Technical recommendations for the cultivation of Broad Beans" , Field Crops Research Institute (FCRI), Agriculture Research Center (ARC), MALR, Egypt (2021), https://www.almasryalyoum.com/news/details/2744841 .

[19] M. S`anchez-Marr`e, "Intelligent Decision Support Systems", S.N. Switzerland AG., 2022.

[20] R. Sharda, D. Delen, E. Turban, Analytics, "Data Science, and Artificial Intelligence: Systems for Decision Support", 11 th ed., Pearson, 2019.

[21] J. Han, J. Pei, H. Tong, "Data Mining: Concepts and Techniques", 4th ed., Morgan Kaufmann, Elsevier Inc, 2023.

[22] R. Rohit, N. Kumar, K. Sandeep, and L. Ramya, "Data Mining and Machine Learning Applications", Wiley-Scrivener, 2022.

[23] T. Padma, Dipali Sinha, "Crop Yield Prediction Using Improved Random Forest", ITM Web Conf., Vol. 56, 02007, 2023, https://doi.org/10.1051/itmconf/20235602007

[24] Ed-Daoudi R. , Alaoui A. , Ettaki B., Zerouaoui J. , "Improving Crop Yield Predictions in Morocco Using Machine Learning Algorithms", Journal of Ecological Engineering 2023, 24(6), 392–400. https://doi.org/10.12911/22998993/162769

[25] Dash R., Dash D., Biswal G., "Classification of crop based on macronutrients and weather data using machine learning techniques" Results in Engineering, Vol 9 (00203), pp 1-8 , Elsevier B.V., 2021.

[26] A. Vogiety, "Smart agriculture techniques using machine learning", international Journal of Innovative Research in Science, Engineering and Technology (IJIRSET), Vol. 9, pp 8061-8064 , 2020 .

[27] K. Akhand, M. Nizamuddin, L. Roytman, “Artificial Neural Network-Based Model for Predicting Boro Rice Yield in Bangladesh Using AVHRR-Based Satellite Data”, International Journal of Agriculture and Forestry, Vol. 8.1, pp 16-25 , 2018.

[28] A. Alqusayr, “Agriculture Investment Projects in Egyptian Vision 2030”, MALR Minister, Alyoum Alsaabie (youm7 News), 12 June 2022, https://www.youm7.com/Article/NewsPrint/5797365

[29] MALR, “The Updated Strategy for Sustainable Agricultural Development in Egypt 2030”, Ministry of Agriculture and Land Reclamation (MALR), Egypt, 2020.

[30] CAMPAS (d), “Egypt in figures 2023, and other previous issues”, Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt, 2023. https://www.capmas.gov.eg/Admin/Pages%20Files/202387133927pop2023.pdf

[31] CAPMAS (E), “Population Clock in Egypt at July 2023”, Central Agency for Public Mobilization and Statistics (CAPMAS), Egypt, 2023, https://www.capmas.gov.eg/Pages/populationClock.aspx

[32] Waikato, “Weka 3.9.6 for Win64 –bits”, Waikato University, New Zealand, 2023