1.1. Computational modeling

Computational modeling is getting importance in social and behavioral sciences studies. Economy globalization, increasing number of international organizations, and fast changes in information technologies are major the factors responsible for altering organizational time scales, natures, complexity, and environments. Timescales have not reduced only, but new organizational forms are emerging and its environments are expanding at unprecedented rates. Computational modeling is the tools which can afford opportunities to both understand and respond to these complex changes in the above situation. Social and organizational investigation are using simulation models for understandings the social or organizational activity and to discover dynamic processes and configurations that are challenging to examine with other existing methods. Computational modeling is increasing effectively for designing and analysis of the organizations. There are many models of computation and these are used in various organizational and social studies but computational modeling in agriculture is still in infant stage that requires great need of improvement in computational modeling for increasing the efficiency at the lower level of errors.

India is essentially an agricultural country with over three-fourths of the population living in rural areas and dependent on agriculture-related occupations. Pre-Independent India was badly hurt by frequent famines and drought. The well-known economist Amartya Sen owes his major works on food shortage to the devastations of the excessive Bengal famine which had made deep impressions on him when he was still a child. If India today is self-sufficient in food, it is in no small measure due to indigenous agricultural research [1].

Development of locally suitable farming systems (FS) is the extreme need of the day, particularly in India where about 87% farms are under
marginal and small holding size. The computational modeling is established through the integration of all independent variables which affect directly or indirectly the output of a system. The verification and validation are the main procedure to simulation models. Computer simulations are best of portraying and comparing theoretical scenarios. It is the research tools which can be used to decrease the massive expenditure in conducting the multiple experiments either in the field or laboratory. This is a very important tool to statistically analysis the effect of different scenarios on the systems and its interaction among themselves.

Computational modeling is increasingly effective for designing and analysis of the system. We have also highlighted the applications of computational modeling in integrated farming system, crops, weather, soil, climate, and statistical used in agriculture for researcher and farmer agricultural community to replace some of the traditional methods.

1.1.2. Need of computational modeling

Computer modeling is having a profound effect on scientific research and so complex that physical experimentation is too time taking or expensive. A computational model can deal with the complication that speaking point of view cannot create good details of the unknown arguments. Then computational models can handle difficulty across multiple levels of examination, allowing data across these levels to be combined and related to each other.

In an agriculture computational model, you can control various new variables more accurately than a real system, and you can replicate results accurately. This permits you to explore the causal role of different components. There are many advantages to using a single computational framework to explain a range of phenomena. In addition to providing a more stringent test of a theory, it encourages parsimony and also enables
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one to relate two seemingly disparate phenomena by understanding them in light of a common set of basic principles.

The use of computational models in the social sciences has grown quickly in the past decades. These models represent a baffling and possibly unapproachable for examining data and developing social organizational and agricultural theory. To address the problems of sustainable economic growth for farming communities in India, farming systems approach is a valuable methodology. Therefore this will play an important role in agricultural growth in the 21st Century, which is essential to make India a developed country.

Indian economy is mainly based on agriculture. The growth rate for overall GDP of India was 8.5% whereas for agriculture and allied sectors it was 10 percent. Sunil Kumar, 2015 studied India is the largest growing country (8°N to 34°N latitude) of the rice under varying climatic conditions and it accounts for more than 40% of food grain production, providing direct employment to 70% people in rural areas. Being the staple food for more than 65% of the people, our national food security hinges on growth and stability of its production [2].

Computational modeling or cognitive engineering and needs sustainable constructs and principles to promote well understanding and forecast of human performance in multifarious systems. The major factor that has contributed to poverty alleviation is the reduced unit cost of production and the downward trend in real prices of food. Low food prices benefited the urban laboring class and the rural landless and marginal farmers who are net buyers of food from the market and poor are able to afford quality food. In upcoming time, rice area expansion sure due to the heavy demand of increased population and urbanization. Therefore, increasing demand has to come from an increase in productivity per unit area. For achieving this, one of the prime requirements and non-monetary
input is transplanting the suitable cultivars at an appropriate time. Three human cognition and performance constructs that have been the subjects of much attention in research and practice over the past three decades are situation awareness (SA), mental workload, and trust in automation [3].

1.1.3. Goal of computational modeling

Modeling has many goals and I can think of models as tools for three things: (1) predicting future outcomes of an exterior reality (2) clarifying and validating theories (3) communication and speech-making.

1.1.4. Brief description in computational modeling

Computational science is the application of computational and so many techniques to solve large and difficult problems. Computational science takes merit of improvements in model and in computer algorithms and mathematical equation. Computational science also allows us to build models that allow us to make predictions of what might happen in the lab or field so that we are perhaps better prepared to make best opinions or to understand better what we are seeing.

A model is a simplified representation of a system and simulation is the study of the system and its behavior using model. Computational models have also been used to estimate national food production and thus aid government policy makers. Combined use of satellite imagery, GIS, and computational model is useful for agricultural mapping potential land productivity and suitability. The computational models for agriculture may help to fill in data gaps that currently exist. Computational models can be used for screening compounds to prioritize those of most interest, as was recently demonstrated by scoring the algorithms of used the farming system. But this dataset may be useful for validating computational models with the caveat that the Integrated Farming System. Computational agricultural models may also helpful for farming systems. Though the review of the literature has been mainly confined to the application of
computational modeling in agriculture, however relevant research work on some other models has also been reviewed and relevant information in the computational model.

We have tried to provide an overview of research into computational models applied particularly in the field of agriculture that details about the important applications of the models and the underlying techniques and assumption from which the models are built. We have also tried to come out with brief understanding for researchers outside the field of computational models on agriculture.

1.1.5. The purpose of computational modeling:

- Analysis and understanding of observed phenomena
- Testing of hypotheses and theories
- Prediction of spatial-temporal systems behavior under various conditions and scenarios (existing and simulated, often performed to support decision making)
- New discoveries of functioning of geospatial phenomena enabled by unique capabilities of computer experiments

1.2. Computer simulation modeling

A computational simulation model is a mathematical model that requires wide computational resources to study the performance of a complex system by computer model. Computational models are created to simulate a set of methods observed in the natural world in order to gain an considerate of these courses and to forecast the result of natural processes given a specific set of input factors [4]. A computer simulation is a simulation, run on a single computer, or a network of computers, to reproduce the behavior of a system as shown in fig. 1.1. The simulation uses an abstract model (a computer model, or a computational model) to simulate the system. Computer simulations are a useful part of mathematical equations of many natural systems in physics, analysis
simplification, real world data and interpretation, human systems in economics, psychology, social science, engineering, and agriculture. Crop growth simulation models are useful tools for considering the complex interactions between a range of factors that affect crop performance, including weather, soil properties, and management. Where pests and diseases are controlled, water and nitrogen fertilizer management are the main factors influencing yield for a given environment. Computational modeling software has emerged as the most popular medium for data analysis and its interpretation. The software comes with various values added features which make simulation software truly multipurpose equipment. Software can be used as a result of the raw data [5].

![Computational Modeling](image)

Fig 1.1 Computational Modeling

### 1.2.1. Crop simulation modeling

A major problem with simulation modeling is the various number of model parameters and input data are required. Even when parameter calibration is sensitivity it allows us to observe where we should concentrate on our calibration and modeling efforts. A Crop Simulation Model is a simulation model that helps estimation crop yield as a function of weather or soil conditions, and choice of crop management practices [6].
Sensitivity means the rate of change in output variable per unit change in input variable or parameter. Sensitivity study of crop simulation modeling involves exploring the behavior of the model for different values of parameters. The basic input requirements of the rice crop model are daily weather data (Latitude, Longitude, radiation, minimum and maximum temperature, rainfall and sunshine hours), experimental data (plant density, date of crop emergence and transplanting, dry matter weights etc) and crop data (cultivar specific, morpho physiologic character of plant species etc.).

1.4. **Types of computational crop modeling:**

Changing markets, technological invention and organizational development in recent years have improved the intensity and scale of agricultural land use. Agrometeorological forecasting is also concerned with the assessment of current and expected crop performance. It used the past and the present weather data and crop data to predict the crop growth and development. The phonological events may be forecasted viz. panical initiation, dough stage, vegetative stage, milking stage, grand growth stage, flowering, silking stage, tasseling stage, fruiting, physiological maturity, and harvesting etc or may be about the predicting crop production. Undoubtedly the economically significant forecasts are the crop yield projections. The impact of weather and climate on crop growth and yield can be represented by crop weather models [7].

Various types of the models documented by are as follows.

1. **Statistical empirical model:** Actual mechanism of processes is not disclosed.

2. **Mechanistic model:** mechanism of the processes involved id discussed e.g. Photosynthesis based model.

3. **Static model:** Time is not a factor.

4. **Dynamic model:** These models predict changes in crop status with time.
5. **Deterministic model**: In which a definite output is given e.g. NPK doses are applied and the definite yields are given out.

6. **Stochastic model**: The probability of occurrence of some event or external variable based model. Probabilities are given out.

1.5. **Approaches to modeling and simulations**

- Real processes are complex and often include non-linear behavior, stochastic components and feedback loops over spatial and temporal scales, therefore models can represent the processes only at a certain level of simplification. Empirical models are based on statistical analysis of experimental data, and they are usually applicable only to the same circumstances under which the observations were made (example of the Universal Soil Loss Equation for modeling annual soil loss based on topography, soil, rainfall and land cover factors)[8].

- Process-based models are based on considerate of physical, chemical, geological, and biological processes and their mathematical explanation (for example, hydrologic and erosion models SIMWE [9]. Models of complex systems often use a combination of empirical and process-based approaches.

The major applications of the models are yield forecasting, yield gap, and yield trend analysis, evaluating agronomic management strategies, evaluation of cropping options in new locations, impacts of climate change on yields, prediction of greenhouse gas emissions, pest and disease management and in according to government planning. However, the impact of the application of the models on decision making by farmers and their advisors and policy makers is generally less clear. Usefulness of models is enhanced if they can be operationalized and harnessed directly or indirectly for farmer’s benefit. In production-oriented agriculture, optimum sowing or transplanting time and suitable cultivars on local area
basis are vital aspects that not only determine farm economy and profitability but also intimately associated with sustainable crop productivity. Simulation modelling has struggled for relevance in real-world agriculture and for impact on farmer decision-making, as outlined in two recent reviews. McCown et al. (2002) reflected on the impacts and learning in emerging and applying computerized decision-support systems through the collated skills from nine substantive efforts of researchers in delivering decision-support systems to farmers [10].

1.6. **Impact of recent advances computational modeling data:**

Computational intelligence, including precise modeling and arithmetical analysis, is always used in economy activities for measurable analysis. For agriculture is so important that almost all states and areas pay special attention to its development. The size of agricultural databases continues to increase and sources of information are growing more and more diversified. This is especially the case for databases dedicated to the traceability of agricultural practices. Some data are directly collected from the field using embedded devices; other data are entered by means of different computer-based applications. Once stored in the same database, all this information must be consistent to guarantee the quality of the data [11].

1.6.1 **Impact on psychological research on agriculture**

Work in computational models of agriculture impacts research in farming systems by transforming how theories are formulated and evaluated. One way this occurs is through a process of concretizing concepts in the theory. Psychological theories of agriculture have typically been cast at an abstract level and through informal (natural language) descriptions. As computational modeling exposes hidden assumptions in the theory, addressing those assumptions can extend the scope of the theorizing. Seen in this way, computational models become not only a way
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to concretize theories, but also a framework for theory construction. Working in the agriculture sector is recognized to be a very physically and mentally demanding job. Within the European agriculture sector, 42% of workers reported that work had a negative impact on their health [12].

1.6.2. Impact on computational modeling of integrated farming systems

Integrated farming systems (IFS) research is a useful tool for expert and user in developing countries such as India. This is a multidisciplinary whole-farm approach and very useful in solving the problems of large, small and marginal farmers. The approach aims at increasing income and employment from small-holdings by integrating various farm enterprises and recycling crop straw and by-products within the farm itself [13].

Farming Systems Research Models: Farming system models are useful in the following ways:

(a) To improve the understanding of farming systems, thereby helping in the prioritization of enterprises, better planning and designing of FS experiments, and farm management and policy development.

(b) To analyses and explain the behaviour of a complex system and to determine the relative importance of different components/enterprises of the systems.

(c) To examine the different scenarios resulting due to integration or mixing of different components or modifying different components in the systems.

(d) To identify the areas where the knowledge of the system is fundamentally lacking.

(e) To improve the system for its large application in under varying resource availability and resource limitations situations.

1.7. Application of computational modeling in agriculture:

Mathews and Stephens 2002 categorized the main applications or needs of models into three categories: as tools in research, education and training and in decision support. Illustrations of research applications
included identification of desired crop genotype characteristics, investigation of management options, cropping or farming system analysis, investigations of impact of climate change on crop productivity, and prediction of greenhouse gas production. Models can be used to assist both tactical decisions making such as irrigation scheduling, fertilizer and pest management, or in strategic decision-making, such as planning for climate change or to avoid salinization, yield forecasting and planning for national food requirements. Models can also be useful in teaching crop and soil processes and crop system behavior in response to weather, management, and site conditions [14].

1.7.1. Yield gap analyses

An important role for crop models is the estimation of yield potential and yield gaps at the site, regional and national levels, identification of reasons for the gaps and evaluation of management options for closing those gaps. Yield potential (Yp), also called potential yield, is the yield of a crop cultivar when grown with water and nutrients non-limiting and biotic stress effectively controlled [15]. Rice and Wheat have been used for determining potential yields and for identifying yield gaps in rice and wheat in many locations of many countries. The results generally reveal large gaps between potential yields and farmer yields. Estimated potential yields of rice in Thailand, finding lower potential yields in the northeast (2 t ha⁻¹) than in the southwest (3.2 t ha⁻¹), and with greater yield variability in the northeast.

1.8. Future thrust of the computational modeling

The emerging trends agricultural economists can make a strong contribution to the development of computational modeling given the long tradition in agricultural economics, productivity, sustainability, profitability and equity for sustainable agricultural development. There is a need to develop extension models based on farming systems approach
using participatory methods incorporating suitable mechanisms for public-private linkages in assessing and transferring appropriate technologies. Local self-government in the form of Panchayati Raj institutions is expected to play an important role in promoting and transferring suitable technologies at village level and generating effective linkages with various development agencies. Inter-sectorial micro level planning for rural development involving different sectors like forestry environment, irrigation agroindustry, health, and education will become a necessity for synergizing their collective output. Combined use of satellite imagery GIS and computational model is useful for mapping potential land productivity and suitability.

1.9. Future Trends

The computational modeling agricultural scenario would be knowledge intensive requiring greater congruence among productivity, sustainability, profitability and equity for sustainable agricultural development. This will warrant effective management to harness knowledge and information from various sources for better farming and improved livelihood and to achieve synergy among farmers, agricultural scientists, extensionists and policy makers. There is a need to develop extension models based on farming systems approach using participatory methods incorporating suitable mechanisms for public-private linkages in assessing and transferring appropriate technologies. Local self-government in the form of Panchayati Raj institutions is expected to play an important role in promoting and transferring suitable technologies at village level and generating effective linkages with various development agencies. Inter-sectoral micro-level planning for rural development involving different sectors like forestry, environment, irrigation, agro-industry, health and education will become a necessity for synergizing their collective output. The modern communication and information technologies have to be
effectively utilized for revitalizing extension systems and knowledge management in India. Effective models expert systems for different crops, weather forecasting, e-learning, and resource databank need to be developed in the form of village knowledge centers. Usefulness of models is enhanced if they can be operationalized and harnessed directly or indirectly for farmer’s benefit. In production-oriented agriculture, optimum sowing or transplanting time and suitable cultivars on local area basis are vital aspects that not only determine farm economy and profitability but also intimately associated with sustainable crop productivity.

1.10. **Constraints based computational modeling for data mining**

Although agent-based models are often regarded as more close to "reality" than are models proposed by computational modeling or classical theories in many disciplines (especially economics and other social sciences), agent-based models still receive a lot of criticism on the methodology, the validity of models. In specialized fields like economics, the approaches to agent rationality are also under critical examination.

A model is a simplified abstraction of the real world. It simulates the behavior of a real system. Modeling begins with the analysis of the systems, its circumstances, and purposes. Defining the model gives insight into the working of the system. So far, the farming systems research has been rather inadequate or slow, particularly in less developed countries. Perhaps the only way by which improvement can be achieved is by the construction and application of suitable whole farm models. Recent computer software development may provide the basis for a start in the modelling of whole farm systems even with incomplete conceptual understanding and data sets.

Computational modeling process may uncover thousands of patterns from a given set most of them to be uninteresting or unrelated to the need of the user. Uninteresting patterns consume more time in analysis
and create confusion to the decision maker. Such unfocused patterns mining can reduce efficiency and usability of the mining process. Often, users have the good sense to select the “line” of mining which may lead to related or interesting patterns. Therefore, a good heuristic is to have the users specify such intuition or expectation as constraints to confine the search space.

1.1. Objectives

The objective of the present study is to discover and analyze complex hidden pattern in the domain data repository through the development of novel computational modeling algorithms. Therefore specific objective has been focused on the study of computational modeling in agriculture, however, all the algorithms developed are general and can be applied for any domain of application involving inter-disciplined independent variables and dependent variable.

Objectives are as follows:

1. To develop and validate the computational model for yield prediction of cropping components of Integrated Farming Systems.

The parameters are as following the objective

1. To study the weather based simulation of phenology, growth, and yield of various cultivars of IFS.

2. To determine and validate the optimum transplanting time for various cultivars of crops and experimental site of Indian Institute of farming system research in IIFSR, Modipuram, Meerut.

3. To develop and manage database repository consisting dependent variable related to crops factor in agriculture.

4. To test all algorithms on crops repository consisting yield factors.

5. To assess the results obtained from the algorithms.