DEVELOPMENT OF DECISION SUPPORT SYSTEM ON PULSE CROPS (COWPEA AND CHICKPEA) IN DHARWAD DISTRICT (KARNATAKA)

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DEVELOPMENT OF DECISION SUPPORT SYSTEM ON PULSE CROPS (COWPEA AND CHICKPEA) IN DHARWAD DISTRICT (KARNATAKA)

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CERTIFICATE

This is to certify that the thesis entitled "DEVELOPMENT OF DECISION SUPPORT SYSTEM ON PULSE CROPS (COWPEA AND CHICKPEA) IN DHARWAD DISTRICT (KARNATAKA)" submitted by Mr. CHIRANJIB DAS for the degree of MASTER OF SCIENCE (AGRICULTURE) in AGRICULTURAL STATISTICS to the University of Agricultural Sciences, Dharwad is a record of research work carried out by him during the period of his study in this University under my guidance and supervision, and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

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JUNE, 2016

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1. INTRODUCTION

Agriculture continues to remain the major sector of Indian economy even after independence. India is the land of agriculture and agriculture is the main occupation for more than 70 per cent of the population of our country. It constitutes 30 per cent to gross national product, provides 65 per cent of employment and continues to be source of living.

There are several opportunities for smallholder farmers to be transformed into medium scale agricultural production. Among different strategies, availing decision support systems for enhancing access to agricultural information and sharing of agricultural knowledge including climate information is vital for realizing improved crop production. However, existing methods for communicating information to smallholder farmers have been found to be not effective for farmers to access timely, understandable and actionable agricultural information and technologies. These methods include radio, television, extension agents and face to face communication (social gatherings at the villages). On the other hand, several software tools have been developed for analyzing different scenarios to generate recommendations and advisories to be used by farmers for optimal crop production.

Despite the development of software tools at the research centres, transferring of technologies developed requires personal communication to farmers and agricultural extension workers at villages. Furthermore, the adoption of these tools remained as a challenge. Low adoption of decision support in agriculture system requires developing improved approaches of Decision Support System (DSS) development. In addition, the approaches for developing decision support system should consider participation of key users.

Computer algorithms have been used in agriculture and allied fields for over thirty years. Areas of usages dealt from computing to the existing multitude of uses in agricultural research such as monitoring, evaluation and control, information management and dissemination, teaching, training and decision support systems. The use of computer algorithms has brought awareness and the potentialities of different disciplines due to possibility of storing and transmitting information.

Information technology (IT) is defined as the technologies involved in collecting, processing, storing, retrieving, disseminating and implementing data and information using microelectronics, optics, telecommunications and computers. The recent advance in computer and communication technology has made computer hardware and software more affordable and user-friendly and has resulted in faster movement of information and its utilization. Computer professionals have started writing programs, which mimic the human thinking. These programs are termed as Decision Support Systems.

A decision support system (DSS) to enhance strategic and tactical decisions that are linked to advance climate information with site-specific relevance. DSS have been applied successfully in agriculture and other sectors such as medical. Such DSS has inadequately addressed strategic and tactical farm level decision in a changing climate. Therefore, in order to improve crop productivity through improving adaptive strategies to climate variability, a web- and mobile- based DSS is essential.

A Decision support system is a computer based information system that supports business or organizational decision making activities. DSSs serve the management, operations and planning levels of organization (usually mid and higher management) and help to make decisions, which may be rapidly changing and not easily specified in advance (Unstructured and semi structured decision problems). Decision support systems can be either fully computerized, human or combination of both.

The term “Decision Support System (DSS)” was coined by Gorry and Mortan (1971). The origin of word is highly informative.

Decision: Emphasizes decision making in problem situation.

Support: Required computer aided decision situation with enough “structure” to permit computer support.

System: Emphasizes the integrated nature of problem solving, suggesting a combined man, machine and decision environment.

DSS include knowledge-based systems. A properly designed DSS is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents and personal knowledge, or business models to identify and solve problems and make decisions.

The concept of decision support has evolved from two main areas of research: The theoretical studies of organizational decision making done at the Carnegie Institute of Technology during the late 1950s and the early 1960s and the technical work on Technology in the 1960s. DSS became an area of research of its own in the middle of the 1970s (Keen, 1978)

According to Sol (1987) the definition and scope of DSS has been migrating over the years. In the 1970s DSS was described as “a computer-based system to aid decision making”. In the late 1970s the DSS movement started focusing on “interactive computer-based systems which helps decision makers utilize data bases and models to solve ill-structured problems”. In the 1980s DSS should provide systems “using suitable and available technology to improve effectiveness of managerial and professional activities”, and towards the end of 1980s DSS faced a new challenge towards the design of intelligent work stations.

While academics have perceived DSS as a tool to support decision making process, DSS users see DSS as a tool to facilitate organizational processes. Some authors have extended the definition of DSS to include any system that might support decision making. Sprague (1980s) defines DSS by its characteristics:-

1. DSS tends to be aimed at the less well structured, underspecified problem that upper level managers typically face;
2. DSS attempts to combine the use of models or analytical techniques with traditional data access and retrieval functions;
3. DSS specifically focuses on features which make them easy to use by non-computer people in an interactive mode; and
4. DSS emphasizes flexibility and adaptability to accommodate changes in the environment and the decision making approach of the user.

Day by day statistical techniques are becoming an inseparable part of every branch of knowledge. Statistical models provide the scientist a powerful tool, allowing predictions about future events to be made with valid information about past or present events. The scientists employ these models either because it is less expensive in terms of time and/or money to collect the information to make the prediction than to collect the information about the event itself. Hence, the statistical models occupy the driver's seat in prediction.

Using statistical model is one of the best ways to gain insight into the complex relations existing between different parameters and production of a particular crop. In the present study multiple regression model is used to know the contributions of weather parameters and area to the production of particular crops. Multiple regression is the functional relationship between several independent variables and one dependent variable.

A large part of increase in agricultural production in India has been attributing to adoption of new seed, fertilizer based technology. Instability means unusually or unnaturally large fluctuation that may lead to serious damage or system failure if allowed to continue beyond a certain limit. It is frequently debated that the new technology had destabilizing effect on production and therefore, the production instability increased during last two decades. This increasing instability leads to wide fluctuations in prices which in turn may lead to inefficiency in production and adverse income distribution. Measurement of instability and identification of its sources are, therefore, the most important areas of study for sustaining and promoting agricultural production. The present study is an effort in this direction.

Instability in time data may be defined as the extent of fluctuations present in observations. Instability between two or more time series data may be compared on this basis. Several authors in the past have tried to study the instability by dividing the whole period into two halves and made comparative study of variability in the two periods. Coppock's instability analysis is one of the instability analysis which was developed by J.D. Coppock in 1962. In the present study this analysis is used. Coppock instability analysis is close approximation of the average year to year per centage variation adjusted by trend.

Agricultural scientists are often interested in explaining or summarizing how parameters concerning agriculture have changed over time and predicting their behavior in future. It is common feature and perhaps meaningful too to associate occurrence of present, being related to occurrence in the recent past, which infact is the essence of Markov chain analysis.

Markov chain is one of the probabilistic measure which can be used in analyzing the current behaviour of some variable in an effort to predict its future behaviour. This procedure was developed by Russian Mathematician Andrey Andreyevich Markov in 1906. In the present study Markov chain analysis is used to identify the direction of change in area of selected crop in Dharwad district of Karnataka.

COWPEA

The cowpea (*Vigna unguiculata*) is one of several species of the widely cultivated genus *Vigna*. It comes under the family Fabaceae. Four subspecies are recognized, of which three are cultivated (more exist including *V. textilis, V. pubescens and V. sinensis*). Cowpeas is well known to be of African native and one of the most important food legume crops in the semiarid tropics covering Asia, Africa, Southern Europe, and Central and South America. It is a drought tolerant and warm weather crop. Cowpeas are well-adapted to the drier regions of the tropics, where other food legumes do not perform well. It also has the useful ability to fix atmospheric nitrogen through its roots nodules and it grows well in poor soils with more than 85 per cent sand and with less than 0.2per cent organic matter and low levels of phosphorus (Singh *et al*., 2003). The name was most likely acquired due to their use as a fodder crop for cows (Michael *et al*., 2007). In addition it is shade tolerant, so is compatible as an intercrop with maize, millet, sorghum, sugarcane and cotton. This makes cowpeas an important component of traditional intercropping system, especially in the complex and elegant subsistence farming system of the dry savannas in sub-Saharan Africa (Blade, 1997). According to the USDA food database, the leaves of cowpea plant have the highest percentage of calories from protein among vegetarian foods. Some well-known common names of cultivated cowpeas include lesera/dangbodi in Assamese, black-eye pea, southern pea, yardlong bean, catjang and Crowder pea. Cowpeas are mostly grown for their edible beans, although the leaves, green peas and green pea pods can also be consumed, meaning cowpea can be used as a food source before the dried peas are harvested (Ehlers and Hall, 1997). It has been estimated that world wide area of production of cowpeas is approximately 10.1 million hectares with annual global grain production being approximately 4.99 million tons. The largest area under cultivation are in Central and West Africa.

The crop was first introduced to India during the Neolithic period and therefore India seems to be a secondary centre of genetic diversity (Pant *et al*., 1982). In India cowpea is grown on an area of 3.9 million hectares with a production of 2.21 million tons with the national productivity of 683 kg per ha (Singh *et al*., 2012). Cowpea, commonly known as "lobia" is used as a pulse, fodder and green manure crop. Being rich in protein and containing other nutrients it is known as vegetable meat. On dry weight basis, cowpea grain contains 23.4 per cent protein, 1.8 per cent fat, 60.3 per cent carbohydrates. This crop's heavy vegetative growth checks soil erosion in problem areas by covering the soil. It has considerable promise as an alternative pulse crop in dry land farming.

In Karnataka area, production and yield of cowpea crop was 79,976 ha, 20,994 tonne and 274 kg/ha respectively. In Dharwad district area, production and yield of cowpea crop was 760 ha, 169 tonne and 234 kg/ha respectively. In Dharwad cowpea crops are grown mostly as mixed crop in both the season *i.e. Kharif* as well as *Rabi.* It is also grown as sole crop. Though it is grown in both the seasons production is lower because area under cowpea crop is very less.(Anonymous, 2012)

CHICKPEA

Chickpea (*Cicer arietinum*) belongs to genus *Cicer,* tribe Cicereae, family Fabaceae, and sub family Papilionaceae. It originated in southern Turkey (Ladizinsky 1975). The name *Cicer* is of Latin origin, derived from Greek word 'kikus' meaning force or strength. Duschak (1871) traced the origin of the word to the Hebrew ‘kirkes’, where ‘kikar’ means round. Chickpea is called poischiche (French), kichar or chicher (German), Chana (Hindi) and gram or Bengal-gram (English). In Turkey, Romania, Bulgaria, Afghanistan and adjacent parts of Russia, chickpea is called as ‘nakhut’ or ‘nohut’ (Van der Maesen 1987).

Chickpea is also called as Ben, is an old World pulse currently. Chickpea is grown in over 50 countries across the Indian subcontinent, North Africa, the Middle East, Southern Europe, the Americas and the Australia. Globally, chickpea is the third most important pulse crop in production, next to dry beans and field pea. Chickpea or chana is a very important pulse crop that grows as a seed of a plant named *Cicer arietinum*. The light brown colored pulse is considered to be a good source of protein and is also called by the name of Garbanzo beans. Chana is used as an edible seed and is also used for making flour throughout the globe. Having a capacity to stand in drought conditions, this crop doesn’t have requirement of being fed with nitrogen fertilizers.

Chickpea is highly nutritious pulse and places third in the importance list of the food legumes that are cultivated throughout the world. It contains 25 per cent proteins, which is maximum provided by any pulse and 60 per cent carbohydrates. There are mainly two types of chickpea produced *i.e.* Desi and Kabuli. Most production and consumption of chickpea (95 per cent) takes place in developing countries. It was grown on about 11.9 million hectares in 2010. Chickpea production has increased over past 30 years from 6.6 million metric tons to 10.0 million metric tons. Most chickpeas are grown in South Asia, which accounts for more than 75 per cent of the world’s chickpea area.

India is the largest producer of chickpea followed by Pakistan, Turkey and Iran and contributing to around 70 per cent of the world’s total production. In India its cultivation was recorded in 200 BC in Uttar Pradesh. According to Decandole, origin of gram is Himalayas Over the period 1978-80 to 2008-10. The area under chickpea in India increased marginally from 7.6 million hectares to 7.9 million hectares but production increased by 40per cent (from 4.8 to 6.8 million metric tons).

In Karnataka area, production and yield of Chickpea crop was 9,69,081 ha, 5,76,871 tonne and 627 kg/ha respectively. In Dharwad district area, production and yield under Chickpea crop was 82,720 ha, 27,520 tonne and 350 kg/ha respectively. In Dharwad chickpea crops are grown mostly as sole crop in *Rabi* season. It is also grown as mixed crop.(Anonymous, 2012)

We need to revamp and revitalize the education service in such a way that it reaches to the farmers / field level workers more effectively. The development of “Decision support system for cowpea and chickpea crops” is an effort in this direction.

Objectives of the study

1. To identify the direction of structural change in the area of selected pulse crops to other pulse crops in Dharwad district.
2. To study the instability in area, production and yield of selected pulse crops
3. To study the impact of weather parameters on the production of selected pulse crops
4. To develop decision support system for the selected pulse crops.

Presentation of the study

The study is presented in six chapters. Chapter 1 gives an introductory note highlighting the rationale of the study, specific objectives, while Chapter 2 represents the reviews of the studies made in the past that are relevant to the objectives of the present investigation. Chapter 3 explains the methodology adopted in the study, including delineation and description of the study area and crops, nature and sources of data, analytical tools and techniques used. The results of the study are presented in Chapter 4 and are discussed in Chapter 5. The summary and conclusions are presented in Chapter 6. References are included after Chapter 6. Some other relevant data and information concerning study is appended at the end.

Limitation of the study

In the present study secondary data based on area, production and yield, was collected for the period of 20 years from 1990-91 to 2009-10, because the recent data of selected pulse crops from 2013 – 2015 as well as 2011 data also on respective parameters were not available.

2. REVIEW OF LITERATURE

The review of literature helps the researcher to get acquainted with subject matter and channelize his efforts in a suitable direction. It forms the basis for interpretation of findings and provides a basic theoretical framework. Mankind could settle and improve living conditions with the advent of agriculture as a feeding resource and profession. The knowledge was acquired through experience and by verbal communication and guidance it was passed from generation to generation. This proclamation of knowledge has been uplifted when mankind started reserving it in the form of books and research papers and intimating through teaching. An explosive trend is started after computers and information technology came into exist. In this aspect of communication many authors imply their own findings through research. The present chapter dealt with different literature propounded by different authors.

2.1 To identify the direction of structural change in the area of selected pulse crops to other pulse crops in Dharwad district

Miller (1952) suggested the use of the conventional least squares estimators as a basis for obtaining the transitional probabilities given that only the proportion of sample in each state for each trial or time period t are known, and assuming a first order Markov chain.

Goodman (1953) recognized the conventional least squares estimator may violate the condition $0 \leq P_{ij} \leq 1$ and suggested that incase the appropriate estimate will lie on the boundary of the restricted parameter subset and concluded that the estimate on the boundary of the subset which minimizes the quadric form should be used.

Anderson and Goodman (1957) estimated transitional probabilities from macro data, when follows an ergodic Markov chain. They provided likelihood ratio tests and χ^2 tests in contingency tables for testing the hypothesis: 1) the first order transition probabilities are time constant; 2) the transition probabilities are specified numbers and 3) the process is a giving order Markov chain.

Fisher (1961) gave an alternative way to derive parameter estimation of transitional probability matrix when equality and inequality restrictions are present is to use the minimum absolute deviations estimators.

Edwards *et al.* (1985) applied Markov chain analysis to study the changing distributions of farm by size. They had applied the model to a longitudinal data set from 1974-1978 collected from the census of agriculture. The model predicted reasonably well for the actual changes during 1978-82. The results indicated that the future distribution of farms by acres per farm would be more like the present the then present was like the past.

Ananthi (2000) analyzed the direction of trade of Basmati and non-basmati rice in India using Markov chain analysis the study period was 1987 – 88 to 1998 – 99. The results indicated that in the countries such as Saudi Arabia, UAE and UK shows the probability of getting more share of import at the cost of countries such as Bahrain Kuwait and USA. In the case of non-basmati rice all the major countries which import Indian rice will lose their share and the probability of the minor countries importing at present may be dominant over the other countries.

Ashalatha (2004) analysed the probability retention using Markov chain analysis in cashew during 1995-96 to 2002-03. It was observed that the USA and Netherlands are stable importers of Indian Cashew kernel with high probability of retention while Australia is moderately stable importer. UK, Japan, UAE and Singapore were the unstable importers. USA and Netherlands will continue to be the major importers of Indian cashew kernel in future also although other importers like UK, Japan, UAE, Singapore and Australia are likely to increase their share at the cost of USA and 'Other countries'.

Raghavendra (2004) assessed the competitiveness of Karnataka's important crops in pre and post liberalization. A policy analysis matrix approach found that the NPC value for important crops of Karnataka was less than one in post liberalization period except groundnut EPC and DRC values also less than one in post liberalization period. From this he concluded that all important crops except groundnut are competitive in Karnataka.

Savadatti (2006) who employed Markov chain model to analyse the direction and changing pattern of export of Basmati rice for the period 1980-81 to 2000-02. The results revealed that there are five major countries importing Indian Basmati Rice, namely Saudi Arabia, Kuwait, UK, USA and UAE accounted for 80 to 90 per cent in 2000 - 2001. The export would likely to be concentrated in Saudi Arabia and Kuwait in the future.

Mahendra (2010) conducted a research on Projection of potato from India: A Markov chain approach. In this study researcher analyses the trends in area, production and yield of potato during 1950–51 to 2006–07 in India. The growth in value of output from potato and its comparison with fruits and vegetables and total value of output from agriculture was estimated during 1999–2000 to 2005–06 in major potato growing states in India and structural changes in composition of various products of potato were also predicted till the end of XI th Five Year Plan by using Markov chain approach. The study reveals that the annual compound growth in area, production and yield was lowest in post WTO period (1997–2006) in comparison to any sub-period or entire period of the study. The analysis of the export composition of potato products reveals that the share of potatoes, fresh or chilled, and potatoes other than seed potatoes, fresh/chilled, declined while share of flakes, granules and pellets of potatoes had increased substantially during 2003–07. Finally the researcher concluded by saying that Nepal, Sri Lanka, Mauritius, Malaysia, Singapore and United Arab Emirates are projected as reliable markets for potato products till the end of XIth Five Year Plan.

Senthilvelan *et al.* (2012) applied Markov chain model for chances of weekly rainfall in Orathanadu Taluk, Thanjavur District, and Tamil Nadu. In this research, Markov Chain Model has been used to study spell distribution. For this purpose a week period was considered as the optimum length of time. the study was carried out for finding the chances of occurrence of wet week (w), wet week preceded by wet week (w/w) at different threshold limits of 10 and 20 mm. based on the analysis the following conclusions are made: (a) 3 and 3½ month varieties are best suited for vettikkadu region; (b) 3½ and 4 months paddy varieties can be grown successfully in neivasal thenpathi area and (c) 4 and 41/2 months paddy varieties are grown favorably in orathanadu region.

Vijaykumar (2012) conducted a research study on the export data on fresh and dried grapes (raisins). The data were collected for the period of 1987-2011 and future export values were predicted. The data was used to find out the transitional probability matrix and for compairing different growth models. For transitional probability matrix researcher used Markov chain model.

Suresh banu (2013) conducted a research on multivariate analysis to study the impact of weather parameters on rain fed crops of Dharwad district. For objective of the researcher transitional probability matrix were applied to know the shift in area and result depicted a broader idea of change of the direction of area over a period of last twenty years. It was revealed that the retention of area was almost similar for all the selected crops in Dharwad taluk except Sorghum crop which noticed highest retention of area in case of Hubli, Kundagol and Navalgund taluks and Paddy crop had maximum retention of area in Kalaghatgi taluk.

Nema (2013) applied the Markov chain approach to know the dry and wet spell rainfall probabilities in planning rain fed rice based production system. In this research Markov chain model was used to find the initial and conditional probability of occurrence of dry and wet weeks, onset and withdrawal of rainy season and weekly analysis of rainfall for Varanasi region. The mean annual rainfall of Varanasi was found to be 1012.8 mm and coefficient of variation (CV) of 19.1 per cent. The data on onset and withdrawal of monsoon reported that rainy season starts effectively from 26th standard meteorological week (SMW) (25 June-01 July) and remain active up to 42nd SMW (15-21 Oct). During rainy season, except during 40th to 42nd SMW, the probability of occurrence of wet week is more than 50 per cent. Finally researcher suggested different crop management strategies as well as remedies for optimal use of rainfall received during the monsoon season and maximize the crop production.

Mourad Lazri *et al.* (2015) studied the trends in drought in northern Algeria. They marked the region by a wide-ranging, severe and persistent drought due to its extraordinary rainfall deficit. In this research, drought classes are identified by using standardized precipitation index (SPI) values. A Markov chain approach was applied to discern the probabilistic behaviour of the time series of the drought. Thus, a matrix which is called transition probability matrix was constructed from drought distribution maps. In drought types and the distribution area the trends in changes are analyzed. The have concluded by saying that the probability of class severe/extreme drought increases considerably rising from the probability of 0.2650 in 2005 to a stable probability of 0.5756 in 2014.

2.2 To study the instability in area, production and yield of selected pulse crops

Achoth *et al*. (1988) analysed the growth and variability of pulse production in Karnataka for the period 1965-66 to 1985-86. The period 1965-66 to 1974-75 was considered as the green revolution decade and 1975-76 to 1985-86 as the decade following the green revolution. The statistical identities suggested by Hazell (1982) were used in this study to obtain a decomposition of the components of change in the variance of total pulse production between two periods in 10 districts of Karnataka. From the study, it was concluded that Karnataka registered a significant increase in pulse production, which has been largely yield induced in four of the major pulse producing districts. The change area variance was identified as the single largest component contributing to instability of pulse production in the state.

Narender *et al.* (1989) examined spatio-temporal variations in crop production growth and the contribution of individual components to overall output growth in Andhra Pradesh by decomposition analysis. The study period 1956-81 was divided into four sub-periods relating to various development stages in the introduction and uptake of HYVs. Output growth rates displayed fluctuation over time and large variation between districts. Changes in the cropping pattern made the greatest contribution to increased output followed by yield increases. Area recorded a negative contribution to output growth.

Pal and Sirohi (1989) opined production instability arising from improved technology may adversely affect production efficiency and income distribution through wider price fluctuation. Two time periods (1950-51 and 1964-65) corresponding to pre and post technology periods, were considered in the analysis of the nature and causes of growth and instability. The variance of production is decomposed into its constituent components using Bornstedt and Goldberger expression for the covariance of the products of two random variables. Yield instability was found to be the main source of production instability for all the crops except sugarcane. The contribution of yield instability to production did not increase during the post technology period. However, area and yield became more covariate over time for all the crops.

Naidu and Munikrishnudu (1991) used both linear and exponential growth functions to estimate and compare growth and instability in agricultural production in Chitoor district of Andhra Pradesh for the two time periods viz., period I (1954-55 to 1964-65) and period II (1965-66 to 1985-86). Their analysis is revealed more of ‘area effect’ than ‘yield effect’ in the growth rate of output of all crops except sugarcane in the pre-green revolution period. But it was vice-versa in the post-green revolution phase (period II) in respect of all crops except groundnut and sugarcane.

Archana and Srivastava (2003) attempted and empirical analysis of growth rate and instabilities in sugarcane production in different regions in Uttar Pradesh, India. The study used time series data on area, production and productivity of sugarcane for western, eastern and central (including Bundelkhand) regions as well as for the state with reference to the period (1980-91 to 1998-1999) and is based on the data from secondary sources. Instability in area, production and productivity was measured through coefficient of variation analysis using detrended data. The production instability was also decomposed to examine the magnitude of various components of regional sugarcane production variability. The study suggested adequate measures to improve location specific production technology through research, development of extension efforts and also through input supply mechanism.

Balamirtham (2003) conducted a research on “Growth instability and supply response of Banana in Kanyakumari district”. To reach the specific objective researcher utilizes the techniques of coefficient of variation and Coppock’s instability index. Data was collected for the period of 1970-71 to 1999-2000 and divided into two sub-periods viz: 1970-71 to 1984-85 and 1985-86 to 1999-2000. According to estimates Coppock instability index, a declining trend in production instability is observed with respective banana production. During the I sub-period the Coppock instability index of area under banana in Kanyakumari district is got as 15.14 while the value of the same index during the II sup-period has been computed as 37.44.

Rao and Raju (2005) studied the path and decomposition analyses of oilseed (groundnut, castor bean, rapeseed, Indian mustard, sunflower, safflower, soybean, Niger and linseed) production in Andhra Pradesh, India. The study covered 23 districts from the regions of Coastal Andhra, Rayalaseema and Telangana, and Andhra Pradesh as a whole. The production period was divided into period I (1981-82 to 1990-91), period II (1991-92 to 2000-01) and overall period (1980-81 to 2000-01). Among the districts, area was significantly correlated with production in 21 districts, whereas productivity was registered in 18 districts. Among the region, area and productivity were positively and significantly correlated with production in all the regions.

Amarender and Devraj (2006) conducted a research study on “Growth and instability in Chickpea production in India: A state level analysis”. Researcher applied Coppock’s instability index and observed that overall instability was higher in production than area and yield at all India level. Instability was higher in second period than first period. Instability in yield was higher than area and it was contributing more to the production instability in both the periods. Instability of yield was increased and area was decreased in the second period compared to first period. However in some states like Tamil Nadu, Rajasthan, Haryana and Gujarat instability was higher than yield instability.

Vasudev *et al.* (2012) studied a research on “Growth in food grain production in India is technology led or policy led: special reference to Andhra Pradesh with district wise economic analysis”. They used time series data for the period of 20 years from 1990-91 to 2009-10. To reach their objective they applied Analytical tools like Hierarchical and K- Means Clustering, Compound Growth Rate, Coppock’s Instability Index (CII), Decomposition of change in average production. For analyzing Coppock’s instability index data period was sub-divided into two periods each of 10 years viz. period I (1990-91 to 1999-2000) and period II (2000-01 to 2009-10). Their result revealed that country as a whole, during the period -I, productivity variability had more influence on production fluctuations than by instability in area. During the period -II also instability in productivity has more influence on production variability than by instability in area. Inter period comparison revealed that instability in production and productivity during the period-II was less than period-I. State as a whole, during both periods, productivity variability had more influence on production fluctuations than by instability in area. Inter period comparison revealed that instability in production and productivity during the period-II was less than period-I. Among the regions, during the period -I, the lowest instability in area, production and productivity were recorded in Coastal Andhra. Highest instability in area and productivity were recorded in Rayalaseema. In 19 districts, out of 22, production fluctuation was more influenced by instability in productivity than variability in area.

Shaikh and Joshi (2013) carried out a research on “Analysis of instability and growth rate of cotton in three district of Marathwada” in Maharashtra. By applying Coppock’s instability index they observed that overall instability was higher in case of production than area and yield at all there three districts. Whereas the instability was lower in case of area specially Jalna district followed by Aurangabad and Beed. But Production and yield was highly instable throughout the periods among all three districts. These indicates that as compare to area, production and yield under the cotton crop was highly instable among the 30 years of period which result in low productivity to the cotton growing farmer.

2.3 To study the impact of weather parameters on the production of selected pulse crops

Sanjeeva Rao et al. (1998) studied on the relationship between yield and meteorological parameters of para rubber tree (*Havea brasiliensis*). Relationship have been derived between latex yield of natural rubber trees *Havea brasiliensis* and climatic variables. They applied the multiple regression models to estimate latex yield on a tapping day, with different antecedent weather conditions. In general researchers concluded that maximum temperature, sunshine duration, vapor pressure deficit and pan evaporation showed significant negative correlation with yield, irrespective of the time period considered. Whereas significant positive correlation was observed between latex yield of rubber trees and rainfall beyond a month period.

Bandopadhyay (2006) used multiple linear regression to predict the average-monsoon rainfall using the previous year's data from the corresponding time period. The overall prediction error was found out to be 24.46 per cent and t-values were found non-significant indicating that, none of the months was a good predictor of average monsoon rainfall.

Murthy *et al.* (2008) studied on climate and its variability over the Western Himalaya. In this the temperature trend using moving averages for interval of 3,5,10 years was studied. Considered minimum and maximum temperatures of Ranichuri. The data collected and calculated during 1982-2002, and they concluded that the maximum temperature had shown decreasing trend while the minimum temperature was almost stable during period of study at Hill Campus, Ranichuri.

Mokashi *et al.* (2008) carried out the experiment for five years on sunflower by using four different sowing windows to study the relationship between weather parameters and yield in rabi season during the rainy season from 1999 to 2004 at Dry farming Research Station, Solapur. The minimum temperature had highly significant positive association with grain yield at all the phonological phases. Relative humidity had significant positive association with grain yield at 4th leaf to 50 per cent flowering stage. Bright sunshine had significant positive association with grain yield. Significant negative association with grain yield by pan evaporation indicates that at early growth stages rabi sunflower not favour moisture stress condition. Significant positive association with grain yield at all stages of growth by minimum temperature indicates rabi sunflower responds well to the low temperature condition throughout growth period. the model on combined effect was developed using stepwise multiple regression for predicting grain yield as Yield = -3015.2008 + 54.9388 X1 +0.4848 X2 +50.8648 X3 +4.3952 X4+26.8468 X5 +19.0967 X6 -24.4833 X7r2 = 0.70.

Khadtare *et al.* (2008) conducted an experiment for five years on sunflower by using four different sowing windows to study the relationship between weather parameters and yield in *rabi* season. The minimum temperature, relative humidity and bright sunshine had highly significant positive association with grain yield at all the phonological phases. Significant negative association with grain yield by pan evaporation indicated that, at early growth stages *rabi* sunflower not favoured moisture stress condition. Significantly positive association with grain yield at all stages of growth by minimum temperature indicates *rabi* sunflower responds well to the low temperature condition throughout growth period. The weather parameter influence their contribution and performance of *rabi* sunflower crop sown at different dates of sowing were assessed and the model on combined effect was developed using stepwise multiple regression for predicting grain yield.

Shwetha (2009) studied the impact of rain water harvesting on farming economy who used nine models (Linear, Logarithmic, Power, Compound, S-curve, Logistic, Growth, Exponential and Inverse models) and observed that linear model was showing significant and best model. The R-square was used to compare and choose the best fit model. The variation in ground water level was found to increasing over the periods as the temperature increases.

Chikkeshkumar (2010) revealed that there is an association between weather parameters and crop yield. Among selected weather variables rainfall is positively and maximum temperature is negatively correlated with crop yield. The models were built in order to predict yield with the help of individual weather parameter. Best models were selected based on the significance of the variable and R^2, which explains the variation in dependent variable due to independent variables. Different nonlinear models were used for predicting yield using each weather parameter, among those, power, compound, cubic, s- curve, logarithmic and quadratic models were found significant.

Sandhu *et al.* (2013) conducted a study on effect of intra seasonal variability in Meteorological parameters on rice productivity in Central Punjab. The 12 years (2000-11) data was collected from Ludhiana districts. The rice growing season was divided into three stages (entire rice season, vegetative stage and reproductive stage) and the meteorological data during these stages were correlated with the rice yields. Highly significant (P=0.05) positive correlation was noticed between grain yield and sunshine hours received during entire rice season and vegetative stage of the crop. The maximum temperature during entire rice season and vegetative stage was significantly (P=0.10) and positively correlated with grain yield. During all three stages maximum relative humidity had significantly negative correlation with grain yield rainfall during vegetative stage and numbers of rainy days during reproductive stage were significantly and negatively correlated with grain yield. After studying the deviation of meteorological parameters from reproductive normal during high and low yield years and the correlation of meteorological parameters with rice yield it can be concluded that in the Central parts of the Punjab sunshine hours play major roles in determining the productivity of rice.

Suresh (2013) conducted a research on multivariate analysis to study the impact of weather parameters on rain fed crops of Dharwad district. For this purpose researcher applied Multiple linear regressions indicated that only area and rainfall were contributing significantly to the production of rain fed crops, but relative humidity was also contributing significantly to the production of Paddy crop in case of Dharwad taluk.

2.4 To develop decision support system for the selected pulse crops.

Poonam (1991) developed a prototype decision support system for students PPW”. Researcher used MS-excel, MS-access and visual basic as a plat form for developing the system.

Edward (1992) developed a decision support system to aid weed control in sugar beet. The system was developed to provide information and assist in giving recommendation to sugar beet advisors on appropriate herbicides mixture and sequences for the range of sugar beet weed problems in United Kingdom (UK).

Avinish (1992) developed a decision support system for micronutrient management who used C language as a builder of the system. Six micronutrients were taken into consideration namely Zinc (Zn), Iron (Fe), Manganese (Mn), Copper (Cu), Boron (B) and Molybdenum (Mo). The system has provides the recommendation on micronutrient application in crops on the basis of soil test values. The system also provides the remedial measures for micronutrient deficiency of crops.

Gianluigi (1997) has worked on the use of computer for the analysis of input demand in farm management: A multi criteria approach to the diet problem. The aim of this work was to analyze the feeding pig's problem using an operational research model with several conflicting criteria, economic and nutritional. The multi criteria decision methods, using a common PC program (Excel), became an operationally simple tool to solve feed formulation problems.

Mathews (1999) developed a spatial decision support system for rural land use planning by integrating geographic information system and environmental models with search and optimization algorithms. The decision support system fulfills the need for a tool that allows rural land managers to explore their land use options and the potential impacts of land use change.

Meng Xianxere (2000) reviewed the construction and management of Agricultural Science & Technology database in China and the database development trends across countries of the world, outlines the framework for the further development of agricultural Science & technology database.

Hsien *et al.* (2003) developed introduction to Taiwan Agricultural Pest Database, with the purpose to provide the BAPHIQ and other administrative and research bodies with an inquiry interface for formulating counter policies to pest status and with pest information of crop as requested by imported countries.

Ochola (2004) developed a prototype interaction Spatial Decision Support System (SDSS) to assist land use scientists, Agricultural extension support personnel and farmers to classify and characterize land quality, assess sustainable land management and identify potential land use solutions at the farm recommendation unit and resource management domain levels in Kenya. The system implements a generic land quality assessment framework that integrates farmer-led participatory sustainability assessment with specialist input into a multi-disciplinary perspective.

Runs and Veronica (2004) developed spreadsheet-based data base for assessment of pest and diseases control measures based on the incidence of diseases for the paddy and maize. He used Microsoft excel 2007 for his decision support system.

Larson (2005) developed Cotton Yield Monitor Investment Decision Aid (CYMIDA) to aid for analyzing the cotton yield monitor information system investment choice. The decision aid was developed to meet the need for better educational information about annual ownership costs and required returns for the cotton yield monitoring information investment decision.

Nagendra and Kumar (2005) developed menu based user friendly "Nutrient management decision support system for appropriate use of fertilizer and amendments in agriculture". This has three main modules viz., information manager, recommendation manager and application manager. Recommendation manager is an environment that is equipped with all mathematical functions and models related to soil test based nutrient recommendations. System was developed by using visual basic as platform.

Surapong (2006) developed the Agriculture Database and IT with an objective of providing reliable and timely information on food security and food agricultural practice process and artifact and safety product and traceability.

Ulla and Peter (2006) developed "system for organizing experimental dataset browser". The SFD dataset browser is a tool for viewing and browsing SFD datasets on the World Wide Web, using a standard web-browser such as Netscape Navigator. SFD is a data storage format and associated tools developed for use within agricultural research. Researcher used HTML and CGI programs for the development.

Ganesh (2006) developed "Decision support system "Crop-9-DSS" for identified crop" for the leading crops in Kerala. Which encompass water management, fertilizer management and crop protection system. It was also developed with all modern features like graphics, photos, video clippings *etc.* and the system was developed using Microsoft visual basic as a plat form.

Arthur (2007) developed decision support system entitled "Building decision support system for suitable crop can be grown based on present climatic condition". He used Microsoft excel and ASP.NET as a programming language for his decision support system.

Sieglinde (2007) developed "Computer-aided generation of risk functions for agricultural modeling and decision" to show how different risk tools can help create convenient risk functions by using both empirical data based on the past and parameters subjectively set by experts. He used excel as tool for development and it can be added as 'risk analysis and stimulation add-in Microsoft excel.

Mila and Ramos (2008) developed Database management Tools available from FAO: the Agricultural information management standards (AIMS) website that will allow the sharing, and promote the uptake of common methodologies, standards and applications. And also to facilitate collaboration, partnership and networking among partners by promoting information exchange and knowledge sharing.

Peter (2008) developed a decision support system entitled, "Developing of Computer based information system for assessing applicability of irrigation water depending on its quality". The system used laboratory analysis information, cultivated crops data, soil and agro-climatic characteristics of the region, irrigation technology and some other parameters to give quality of water. He used visual basic for the development.

Ashalatha (2009) developed a system entitled "Development of Database management and statistical analysis through specially designed software". Researcher has created a database system on important crops which would provide information with respect to its scientific name, image, area, production and productivity, varieties grown under different season under irrigated as well as rainfed.

Zhivko *et al.* (2009) developed software for applicability of irrigation water in conformity with its quality with an objective of assessment of the water quality indicators for efficient use of the water resources in accordance with the requirements of the water consumers.

Daniel (2011) developed “Crop nutrient management decision support system” for black gram and paddy in Tamil Nadu. He used the site specific nutrient management as the base for the system and the system was developed in visual basic.

Vishwajith (2012) conducted a research on “Development of Decision Supporting System for Fertilizer Recommendation for Selected Zones of Karnataka”. He applied site specifically to estimate yield of selected crops in response to fertilizer recommendation for the selected zones in Karnataka.

Gurupadappa (2014) developed a system named “Development of Decision Support System for Cotton and Sugarcane” in Dharwad. He used the site to estimate yield of selected crops in response to disease, pest and weed growth and the system was developed in visual basic.

Parvathy (2014) developed Decision Support System which deals exclusively with the farm implements and machinery used in selected crops viz., rice, plantation crops, fruits and vegetables, the system was named as “Farm Mechanization”. Malayalam version of the Decision Support System developed for farmers was named as “Karshika Yanthravalkaranam”. This software was done in such a way so as to work in personnel computer. The user side interface layer was designed using Hyper Text Markup Language (HTML). On opening the software, the end user will be directly taken to the home page of the system. From there the user can navigate to any page inside the system through the corresponding photographic icons.

3. MATERIAL AND METHODS

This chapter has important components of research. To realize the various objectives of the study by using an appropriate methodology to describe the characteristics of the study area, the nature and source of data, and various statistical tools and techniques employed for data analysis. This methodology is described under the following headlines.

3.1 Description of the study area

3.2 Nature and sources of data

3.3 Study period

3.4 Analytical techniques employed

3.1 Description of the study area

An objective assessment of any development activity can be made only with a thorough understanding of the physical and natural endowments of the region as well as of the population. Dharwad district of Karnataka state, was selected for the study purpose. The map of the study area is shown in Fig. 1. Hence, an attempt has been made to describe the physical, natural and socio-economic features of Dharwad district, which are chosen for the present study.

3.1.1 Karnataka

Karnataka state is one of the 29 states in India located in the southern part of the country between $11^0$31" and $18^0$45" north latitude and $72^0$12" and $78^0$40" east longitude. This state is surrounded by Maharashtra and Goa states in the north, Andhra Pradesh state in the East and Tamil Nadu and Kerala states in the south. On the west, the state opens to the Arabian Sea. The state covers an area of 1,91,976 sq.km which accounts to about 6 per cent of the total geographical area of India.

3.1.2 Dharwad district

Dharwad district is situated in northern part of Karnataka state. The District is lying between the latitudinal parallels of $15^0$02' and $15^0$51'' North and longitudes of $73^0$43' and $75^0$35' East. The district comes under the Northern transitional zone. It is bounded by the Belagavi in the North, Haveri in the South; from Northeast to Southeast bounded by Uttar Kannada district and Northwest to Southwest it is bounded by Gadag district.

The district has healthy and conducive climate. The monsoon varies from April-May to September-October with two peaks, one in July and other in September creating two cropping seasons. The temperature ranges from a maximum of 39^0C to minimum of 13^0C. The types of soil ranges from shallow to black and medium red sandy loam. The annual rainfall ranging from 539.7 mm to 1037.2 mm, which is fairly well distributed from April-May to September-October.

The total geographical area of the district is 4,27,329 ha and about 84.30 per cent area is under cultivation (3,60,186 ha), 8.24 per cent area under forest (35,235 ha), 0.83 per cent under grazing land (3,571 ha) and about 51.5 per cent of the area is sown more than once (2,20,341 ha).

Only 23.53 per cent of the total cultivable area is under irrigation in the district. The major irrigation sources are canals (62,570 ha), bore wells (22,068 ha), tanks (113 ha) and other sources (11 ha).

The principal crops of the district are maize, soybean, cotton, jowar, potato, groundnut, paddy and vegetables in *kharif* season. In Rabi season, major crops grown are wheat, rabi jowar and bengal gram.

3.2 Nature and sources of data

Secondary data

Secondary data for a period of 20 years from 1990-2009, on the respective parameters were collected from different sources for the purpose of analysis. Different sources are

Area, production and yield data:

- Karnataka at A Glance: Government of Karnataka.
- District Statistical Office, Dharwad.
- http://www.indiastat.com website.
- Joint Directorate of Agriculture Office, Dharwad.
- Directorate of Economics and Statistics, Bangalore.

Weather data:

- Main Agricultural Research Station (MARS) Dharwad.
- http://www.indiastat.com website.

The package of practices for cowpea and chickpea were collected from University of Agricultural Sciences, Dharwad and Tamil Nadu Agricultural University Agritech. Website and internet.

Different parameters considered for the research study are as follows:

Y = Production (tonne)

X_1 = Area (ha)

X_2 = Maximum Temperature (^0C)

X_3 = Minimum Temperature (^0C)

X_4 = Relative Humidity (per cent)

X_5 = Rainfall (mm)

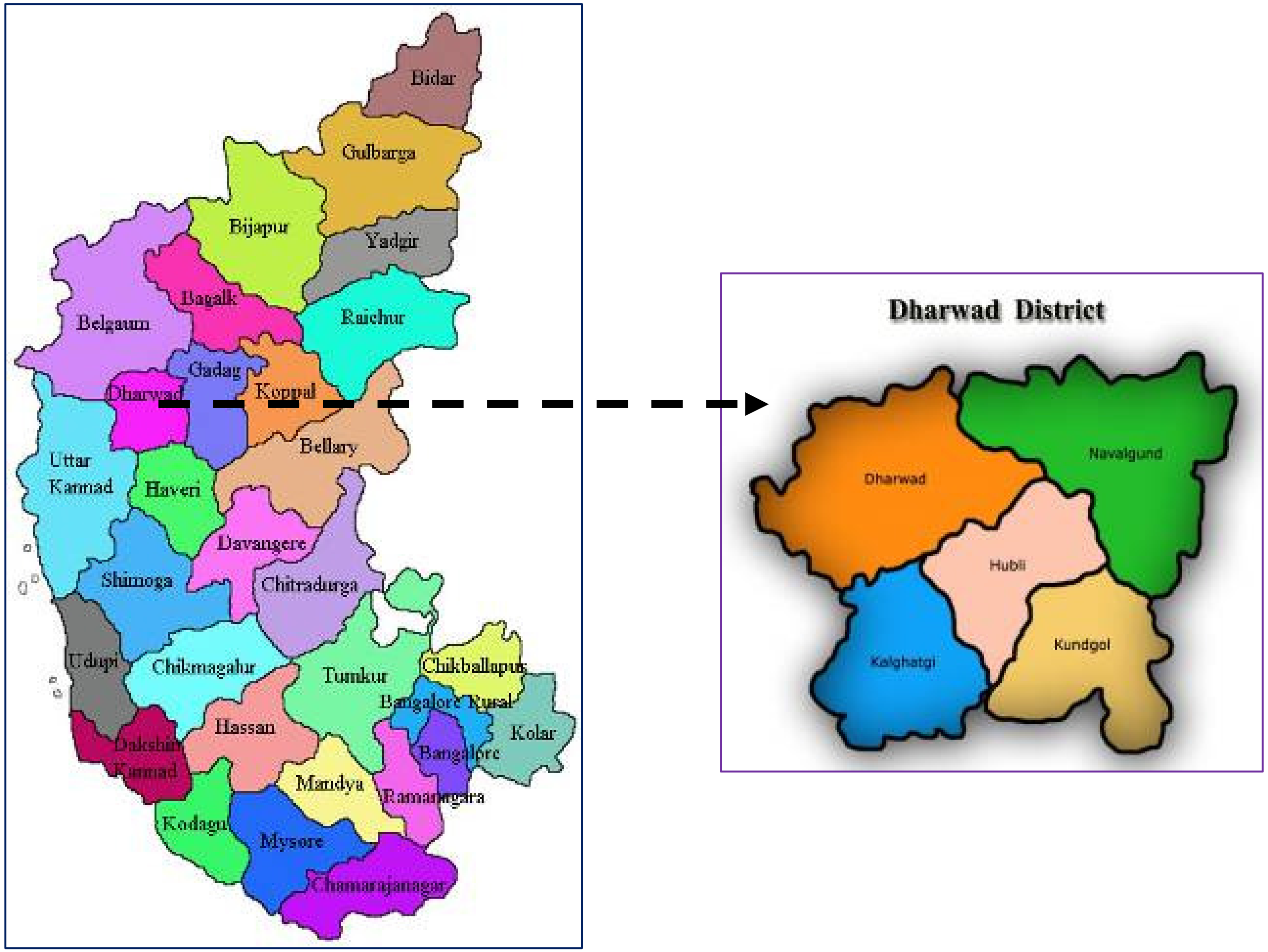


Fig. 1: Map showing study area

3.2.1 Measurement of Variables

Weather parameters

Weather parameters X_2 to X_5 were recorded according to the standard method described below:

X_2 and X_3: Temperature

The temperature *i.e.* the maximum temperature (X_1) and minimum temperature (X_2) were recorded with the help of thermometer and units were in Degree Celsius (^{0}C).

X_4: Relative Humidity

Through sling psychrometer relative humidity is measured and recorded in per centage.

X_5: Rainfall

Rainfall data was recorded by using standard rain gauge in millimeter.

3.2.2 Crop Data

Crop data were collected based on the parameters area (ha), production (tonnes), yield (kg/ha) from different secondary sources which are already listed above in 3.2

Selected crops for research

1. Cowpea
2. Chickpea

3.3 Study period

The secondary data were collected for the period of 20 years from 1990-1991 to 2009-2010 for the study of selected pulse crops *i.e.* Cowpea and Chickpea on area, production, yield and weather parameters in Dharwad district.

3.4 Analytical techniques employed

To examine the different objectives of the present study the data were further processed, tabulated, and classified. Different statistical treatments were employed to respective objectives for analyzing and interpreting the results.

3.4.1 To identify the direction of structural change in the area of selected pulse crops to other pulse crops in Dharwad district.

The structural change in area was examined by using the Markov chain approach. Objective to Markov chain analysis is the estimation of the transitional probability matrix P. The element P_{ij} of the matrix indicates the probability that area will structurally change from district i to j with passage of time.

MARKOV Chain analysis:

Markov chain process is one of the probabilistic measures which can be used in analyzing the current behaviour of some variable in an effort to predict its future behaviour. This procedure was developed by Russian Mathematician Andre A. Markov in 1912.

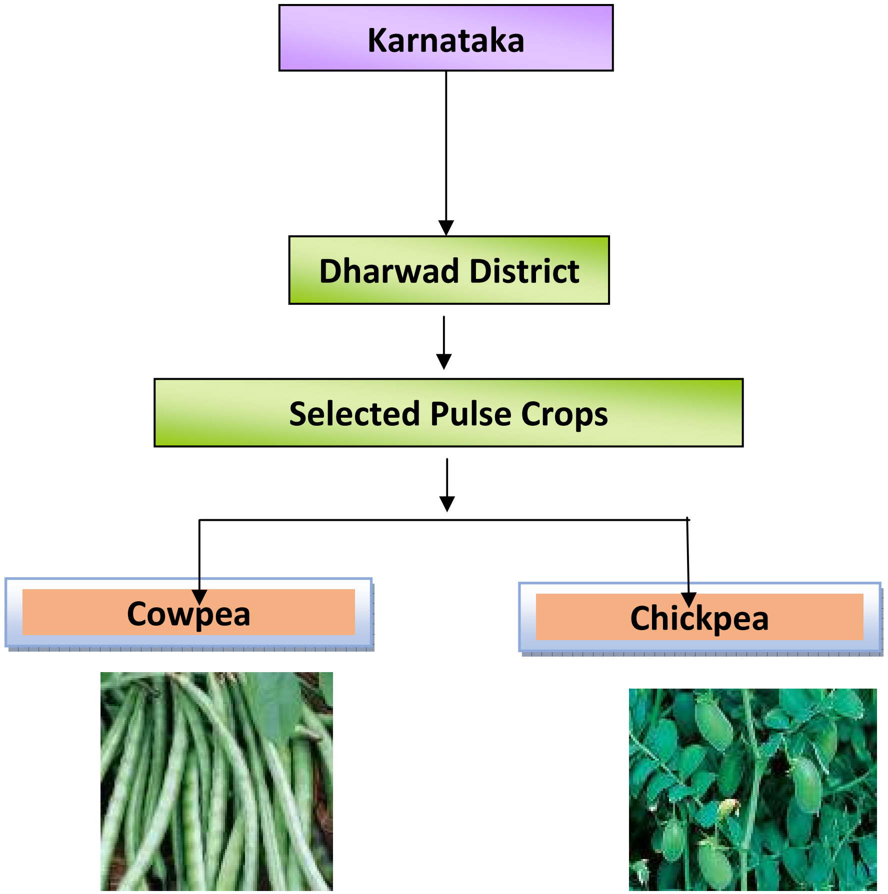


Fig. 2: Sampling frame

Agricultural scientists are often interested in explaining or summarizing how parameter concerning agriculture have changed over time and predicting their behaviour in future. It is common feature and perhaps to associate occurrence of present, being related to occurrence in the recent past, which in-fact is the essence of Markov chain analysis.

A Markov chain is one particular type of stochastic process. Any sequence of trails or experiments that can be subjected to probabilistic analysis is called as stochastic process. Stochastic models are particularly useful to researcher concerned with problems of movement. The structural change in area of selected crop was examined by employing first order finite Markov chain model which captured the net effect in changes in area over a period of time.

The structural change in area of pulse crop was examined using the Markov chain approach. Main focus of Markov chain analysis was the estimation of the transitional probability matrix P. The element P_{ij} of this matrix indicates the probability that areas of pulse crop will switch from i th crop to j^{th} crop with the passage of time. The diagonal P_{ij} measures the probability that area share of a crop would be retained in successive time periods. Hence the examination the diagonal element indicates the loyalty of shifting of areas of a crop to a particular crop.

$$E_{jt} = \Sigma E_{jt-I} * P_{ij} + e_{jt} \ (i = 1,2,\ldots..n)$$

Where, i and j are crops, t is time period

E_{jt}=Area under j^{th} crop during period t

E_{jt-1} =Area under j^{th} crop during period t-1

P_{ij}= Probability of shifting area from i^{th} crop to j^{th} crop.

e_{jt} = The error –term which is statistically independent of e_{jt-1} , and

n= Number of crops.

The transitional probabilities P_{ij} which can be arranged in a (c*r) matrix, had the following properties;

1) $0 \le P_{ij} \le 1$

2) $\sum_{i=1}^{n} P_{ij}=1$ for all i

hus, the expected area shares of each crop during particular period t can be obtained by multiplying the area to the selected crops (five in the present study) during the previous period (t-1) with the transition probability matrix (P).

3.4.2 To study the instability in area, production and yield of selected pulse crops.

Instability in structural change in area is expected to hamper the process of development of crops. To study the area, production and yield instability, Coppock's instability index was used to estimate and compare the variability in areas, productions and yields during the pre and post time period.

COPPOCK Instability Index

This method involves a constant percentage changes from year to year and this is better measure than the constant absolute changes from year to year *i.e.* it is close approximation of the average. Coppock's instability index was developed by J.D Coppock. Coppock index is performed for any time series data. The Coppock's instability index is also called as the log variance method and is expressed algebraically in the following estimable form

CII (per cent) = [(antilog √log v) -1]*100

Where,

$$\log v = \frac{1}{N-1} \Sigma [\log (\frac{X_{t+1}}{X_t}) - m]^2$$

log v = logarithmic variance

N = Number of years in the series.

X_t = Area / production / yield *etc.* in the year't'

X_{t+1}= Area / production / yield *etc.* in the next year't+1'

m = Arithmetic mean of difference between log's of X_{t+1}, t

$$m = \frac{1}{N-1} \Sigma \log (\frac{Xt+1}{Xt})$$

Steps for Calculating CII Percentage

1. Logarithms are obtained for each annual value of a variable for example total exports for Year 1, Year 2 *etc.*
2. The logarithm of the value for year 1 is subtracted from logarithms of the value for year 2 *etc.* in order to get first differences of logarithms.
3. The arithmetic mean of the logarithmic first differences is then obtained.
4. The logarithmic mean is subtracted from each year to year logarithmic first difference in order to obtain the logarithmic difference between the actual and average (trend) year to year logarithmic differences.
5. These logarithmic differences from trend some positive and some negative are then squared, summed up and divided by the number of years minus one. The resulting number is termed as " log - variance"
6. The next step is to take the square root of the log variance and obtain the antilog of the square root value. Unity is then subtracted from antilog and multiply with hundred. The resulting "instability index" is close approximation of the average year to year per centage variation adjusted for trend.

3.4.3 To study the impact of weather parameters on the production of selected pulse crops

For the present objective multiple regression model has been used to know the effect of area and weather parameters (considered under study) on production of selected pulse crops. Weather parameters were rainfall, relative humidity, temperature.

Multiple Linear regression Analysis

When the numbers of variables which explain the dependent variable are more than one multiple regression model is used. Here the model is,

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_P X_P + \varepsilon$$

Where, Y is the dependent variable (Production)

X_i's are independent variables and β_i's as the partial regression coefficients of Y on X_i's where i=1,2,…P.

In the present study, Y is taken as annual production and X_i's are area and weather parameters *viz.*, temperature, relative humidity and rainfall,

X_1 = Area (ha)

X_2 = Maximum Temperature (0^0C)

X_3 = Minimum Temperature (0^0C)

X_4 = Relative Humidity (per cent)

X_5 = Rainfall (mm)

In this model, the estimates of coefficients (βi's and α) were computed by using the method of least squares. The final relation is represented in matrix form as follows:

$$\begin{bmatrix} b_0 \\ b_1 \\ \vdots \\ b_P \end{bmatrix} = \begin{bmatrix} \sum X_0^2 & \sum X_0 X_1 & \cdots & \sum X_0 X_P \\ \sum X_1 X_0 & \sum X_1^2 & \cdots & \sum X_1 X_P \\ \vdots & \vdots & \vdots & \vdots \\ \sum X_P X_0 & \sum X_P X_1 & \cdots & \sum X_P^2 \end{bmatrix}^{-1} \begin{bmatrix} \sum X_0 Y \\ \sum X_1 Y \\ \vdots \\ \sum X_P Y \end{bmatrix}$$

$$\hat{\alpha} = \overline{Y} - \left(b_1 \overline{X}_1 + \cdots + b_P \overline{X}_P\right)$$

The model is tested by using F test and multiple coefficient of determination (R^2)

$$R^2 (\%) = \frac{\text{Regression sum of squares}}{\text{Total sum of squares}} \times 100$$

Based on R^2 value best model is selected and at how much quantity the independent variables are contributing to the dependent variable, was obtained from the model.

3.4.4 To develop decision support system for the selected pulse crops

For this objective a website design has been developed for UASD (University Of Agricultural Sciences, Dharwad). A properly designed DSS (Decision Supporting System) is an interactive software-based system intended to help decision makers compile useful information from a combination of raw data, documents and personal knowledge to identify and solve problems and make decisions. This website is designed based on the details about the selected crops, origin, introduction, botany, soil, climate, seed and sowing, varieties, pests, diseases, weed management, water management, harvesting, area and production and weather parameters. This design is created in such a way that one can provide solution to the crop related problems so that overall agricultural production can be increased in Karnataka and one can give suggestion to the farmers by question and answer forum (Q&A forum) which are already there in the website.

For designing this website, a document is prepared called SRS (Software Requirement System) which contains functional and non-functional requirements.

3.4.4.1 Software Requirements Specification

3.4.4.1.1 Motive of SRS

The motive of this chapter is to mark the requirements of the study which includes non-functional and functional requirements along with the use of case diagram and test cases.

In general the overall aim of this SRS is to provide a detail information of the software product, its parameters and goals. This SRS document helps to assist in software delivery life cycle (SDLC) process to any designer and software developer.

3.4.4.1.2 Operating Requirements

1. Operating System : Windows 8
2. Database Requirement : MySQL
3. Hardware Requirement: Server

3.4.4.2 Requirement Specification

Functional Requirements

1. Crop selection window: Here the user have to select the crop for getting information.
2. Registration window or Sign up window: This window will show to fill the mandatory details for registration purpose.
3. Login or Sign In window: Here user can sign in if user has already registered in this website.
4. Program for Q & A Forum: In this forum user will be able to query any problems regarding the crops.
5. Feedback: In this window experts can give suggestion or feedback to the questions which has been asked.
6. View in Kannad: In this window user will be able to translate the webpage to kannad language.

Software Interfaces

Twitter Bootstrap: Bootstrap is a free collection of some machineries for creating web applications and web-portals. It consist of design templates for typography, HTML (Hyper Text Markup Language) and CSS (Cascading Style Sheets)-based design, forms, buttons, navigation and other interface components.

MySQL: MySQL (My Structured Query Language) is relational database management system which take steps for data definition language to create relations and data manipulation language to execute SQL queries.

3.4.4.3 System Design

Architectural Design: Here the website will be connected to the application layer through HTTP (Hyper Text Transfer Protocol) protocol.

Detailed Design: This design shows the base class which consist of crop, origin, introduction, botany, seed and sowing, varieties, pests, weed and water management and harvesting as sub class.

Sequence Diagram: The diagram shows large scale interaction between objects. The each object send a message or a message call to other object to build interaction. Whenever farmer will request for the particular information, the data will be retrieved from the database and information will be displayed on the web pages.

Data Flow Diagram: This is designated to view the details of the crop, to login procedure and to ask the query about crop related problem and the UASD expert will answer for the respective queries.

3.4.4.4 Database Design

This design is based on ER diagram which describes the entity attributes and the relationship between each entity.

Deployment process of the system

Krushidhama website which is connected to the server with HTTP protocol (Hyper Text Transfer Protocol), in application server business logic will be running to do the specific functions. Required data is retrieved from database.

3.4.4.5 Module description with its input and output

View Details

- Module name : Retrieval of crop information
- Input: Name of the crop
- Output: Detailed information about crop based on category named like origin, introduction, botany, seed and sowing, varieties, pests, weed and water management and harvesting.
- Purpose of the module: Takes the crop name as input and retrieve the detailed information about the respective crop.

Sign Up

- Module name: Registration to the web portal.
- Input: All mandatory details.
- Output: The detailed information about the user will be stored in the database and confirmation mail will be sent to the user.
- Purpose of the module: Takes all details of the user as input and data will be stored in database.

Sign In

- Module name: Sign in into the website..
- Input: User name and Password.
- Output: The Q & A forum will be opened.
- Purpose of the module: Takes User name and password as input which further navigates to the Q & A forum.

Q & A forum

- Module name: Question and Answer forum.
- Input: Query/reply data
- Output: The query/reply data will be uploaded into the forum.
- Purpose of the module: Takes query/reply data as input and data will be stored into the web-portal so that all users can view questions along with answers and UASD members can reply the queries.

Message Notification

- Module name: Sending message notifications to all registered users.
- Input: Text data.
- Output: The message will be sent to all registered farmers.
- Purpose of the module: Takes text data as input from UASD member whenever there is change in the database and the text message will be sent to the all registered farmers so that they can easily know about the changes in database

Feedback

- Module name: Giving feedback and getting notification.
- Input: Text data
- Output: The feedback data will be stored into the portal and confirmation notification will be sent.
- Purpose of the module: Takes text data as input and data will be stored into the portal, the notification will be sent via email.

Area & Production Details

- Module name: Area and Production
- Input: Crop name, district name and year.
- Output: Area and Production details will be displayed.
- Purpose of the module: Takes crop name, district name and year three inputs and information about area and production will be displayed in ha and kg/ha respectively.

Weather information

- Module name: Weather data
- Input: Crop name, year and month.
- Output: The weather details will be displayed.
- Purpose of the module: Takes crop name, year and month three inputs and information about weather will be displayed.

View details in Kannada

- Module name: Kannada data retrieval.
- Input: Crop name.
- Output: Detailed information about crop based on category named like origin, introduction, botany, seed and sowing, varieties, pests, weed and water management and harvesting in Kannada.
- Purpose of the module: Takes the crop name as input and retrieve the detailed information about the respective crop in Kannada.

4. EXPERIMENTAL RESULTS

This chapter, concerns with the presentation of findings emanated from the study. The presentations of the findings of the study have been made under the following major heads.

4.1 Identifying the direction of structural change in the area of selected pulse crops

4.2 Instability of the selected pulse crops

4.3 Impact of weather parameters on the production of selected pulse crops

4.4 Development of decision support system

4.1 Identifying the direction of structural change in the area of selected pulse crops

The structural change in area under pulse crops in Dharwad district was examined by Markov chain analysis *i.e.* through the transitional probability matrix. The transitional probabilities were presented in matrix form in the Table 4.1.1.The transitional matrix showed a wide idea of shift of area over a period of twenty years. The major pulse crops, taken for the objective were chickpea, cowpea, arhar / tur, horse gram, green-gram / moong. In the transitional probability matrix the diagonal elements indicating the probability of shift in area of a crop would be retained in successive time periods and the elements in column indicate the probability of gain in area from other crops.

It is revealed from the Table 4.1.1 that the highest holding or retention of area was noticed in case of chickpea crop which is about 73.24 per cent followed by green gram (70.24 per cent), horse gram (42.11 per cent) and no retention was found in case of cowpea (0.00 per cent) and arhar (0.00 per cent). To hold their share, chickpea crop has gained area at about 91.61 per cent form arhar crop, which is quite higher, 54.86per cent from horse gram and 25.57 per cent from green gram crop. At the same time chickpea crop losts 1.33 per cent area to cowpea, 5.35 per cent to arhar, 4.51 per cent to horse gram and 15.57 per cent to green gram crop. Cowpea crop has gained area of 1.33 per cent from chickpea crop, 3.03 per cent from horse gram and 1.82 per cent from green gram and at the same time it has lost its 100 per cent to green gram crop. In case of arhar crop, it has gained area of 5.35 per cent from chickpea and 2.37 per cent from green gram crop and at the same time it has lost its area to chickpea crop at 91.61 per cent which is quite higher and 8.39 per cent to horse gram. Horse gram crop has gained area at 4.51 per cent from chickpea and 8.39 per cent from arhar and it has lost its area to 54.86 per cent to chickpea crop and 3.03 per cent to cowpea crop. While green gram has gained much to the extent of 100.00 per cent from cowpea and 15.57 per cent from chickpea crop.

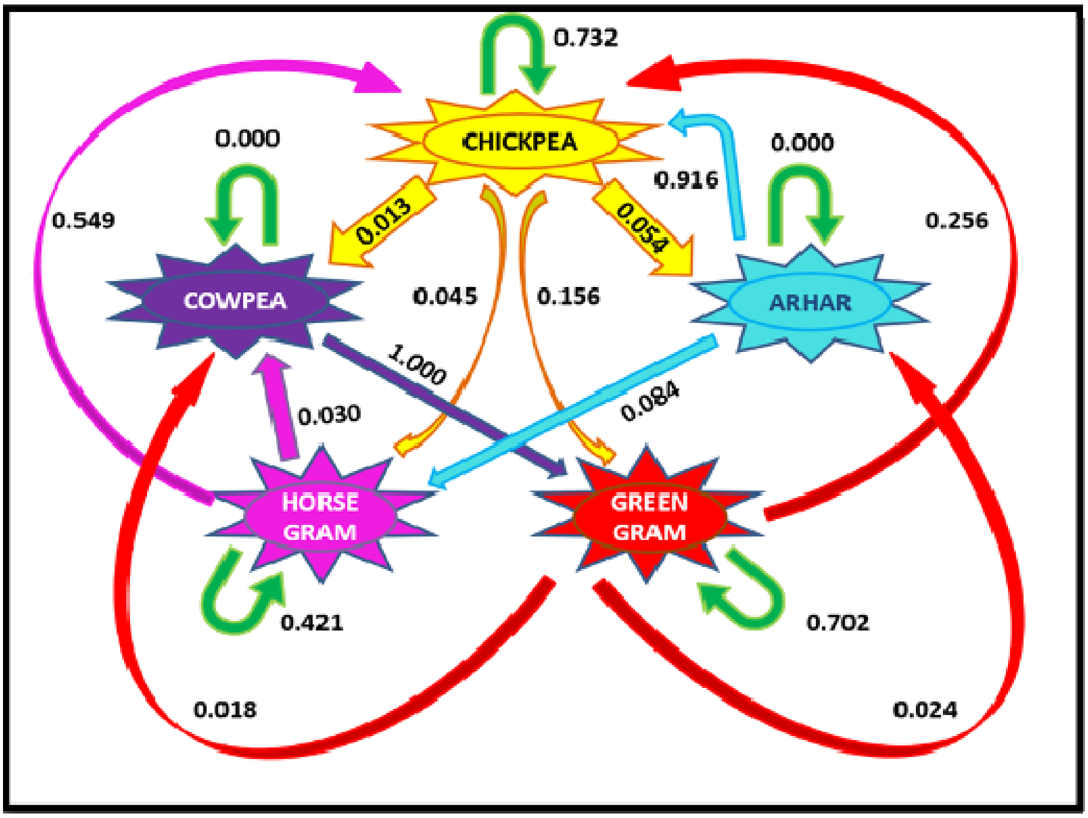
It has been observed that overall gain in area was higher for chickpea crop from other crops considered under study which is in total about 1.7204 *i.e.* 172.04 per cent followed by green gram about 115.57 per cent , horse gram (12.90 per cent), arhar (7.72 per cent) and cowpea which is lowest in gaining area which is about 6.18 per cent.

Table: 4.1.1 Transitional Probability Matrix for shift in area of pulse crops in Dharwad District.

SHIFT →

GAIN ↓

	Chickpea	Cowpea	Arhar	Horse gram	Green gram
Chickpea	**0.7324**	0.0133	0.0535	0.0451	0.1557
Cowpea	0.0000	**0.0000**	0.0000	0.0000	1.0000
Arhar	0.9161	0.0000	**0.0000**	0.0839	0.0000
Horse gram	0.5486	0.0303	0.0000	**0.4211**	0.0000
Green gram	0.2557	0.0182	0.0237	0.0000	**0.7024**



NOTE:

Retention in area of selected crops

Shifting of area from Chickpea crop

Shifting of area from Cowpea crop

Shifting of area from Arhar crop

Shifting of area from Horse gram crop

Shifting of area from Green gram crop

Fig. 3: Retention and Shifting of areas among selected pulse crops in Dharwad district.

4.2 Instability of the selected pulse crops

Coppock's Instability index was used to know the instability of the selected pulse crops (cowpea and chickpea)

4.2.1 Instability on area, production and yield of Chickpea crop in Dharwad district.

Table 4.2.1 revealed that overall instability is higher in yield which is 153.07 per cent than area (31.76 per cent) and production (136.18 per cent). Overall contribution of yield for instability of production is higher than area. Whereas in period I the instability is lower in the case of yield which is 46.66 per cent than production (59.38 per cent) but higher than area (40.26 per cent). Here also in period I contribution of yield for instability of production is higher than area. In case of period II again instability is higher in yield about 264.14 per cent than area (18.74 per cent) and production (216.09 per cent). Here contribution of yield is more than area for instability to the production. But production and yield is highly instable throughout periods under the study in Dharwad district. These indicates that as compare to area, production and yield under the chickpea crop is highly instable among the 20 years of period which result in low productivity to the chickpea growing farmer.

4.2.2 Instability on area, production and yield of Cowpea crop in Dharwad district.

Table 4.2.2 revealed that overall instability is higher in production which is 29.80 per cent than area (27.13 per cent) and yield (24.42 per cent). Overall contribution of area for instability of production is higher than yield. Similarly in period I the instability is higher in the case of production which is 57.19 per cent than yield (41.22 per cent) and area (30.79 per cent). Here in period I contribution of yield for instability of production is higher than area. In case of period II again instability is higher in production about 25.96 per cent than area (21.04 per cent) and yield (22.01 per cent). Here contribution of yield is more than area for instability to the production. But production is slightly instable throughout periods under the study in Dharwad district. These indicates that as compare to area, production and yield under the cowpea crop is slightly instable among the 20 years of period which result in low productivity at some extent to the cowpea growing farmer.

4.3 Impact of weather parameters on the production (tonne) of selected pulse crops

To study the impact of weather parameters, considered under study on the production of selected pulse crops Correlation coefficients and multiple regression analysis was carried out.

In this case the production of pulse crops (chickpea and cowpea) was considered as dependent variable and independent variable were area, maximum temperature, minimum temperature, relative humidity and rainfall. The results are presented in the following Tables; 4.3.1, 4.3.2, 4.3.3 and 4.3.4.

In Table 4.3.1 it is observed that, the correlation coefficient of area, maximum temperature, relative humidity and rainfall were positively correlated with production of Chickpea and the minimum temperature showing significant negative correlation with the production of Chickpea crop.

Table 4.2.1 Instability on area, production and yield of Chickpea crop in Dharwad district.

(Values in percentage)

	Area	**Production**	**Yield**
Period 1	40.26	59.38	46.66
Period2	18.74	**216.09**	**264.14**
Overall	31.76	**136.18**	**153.07**

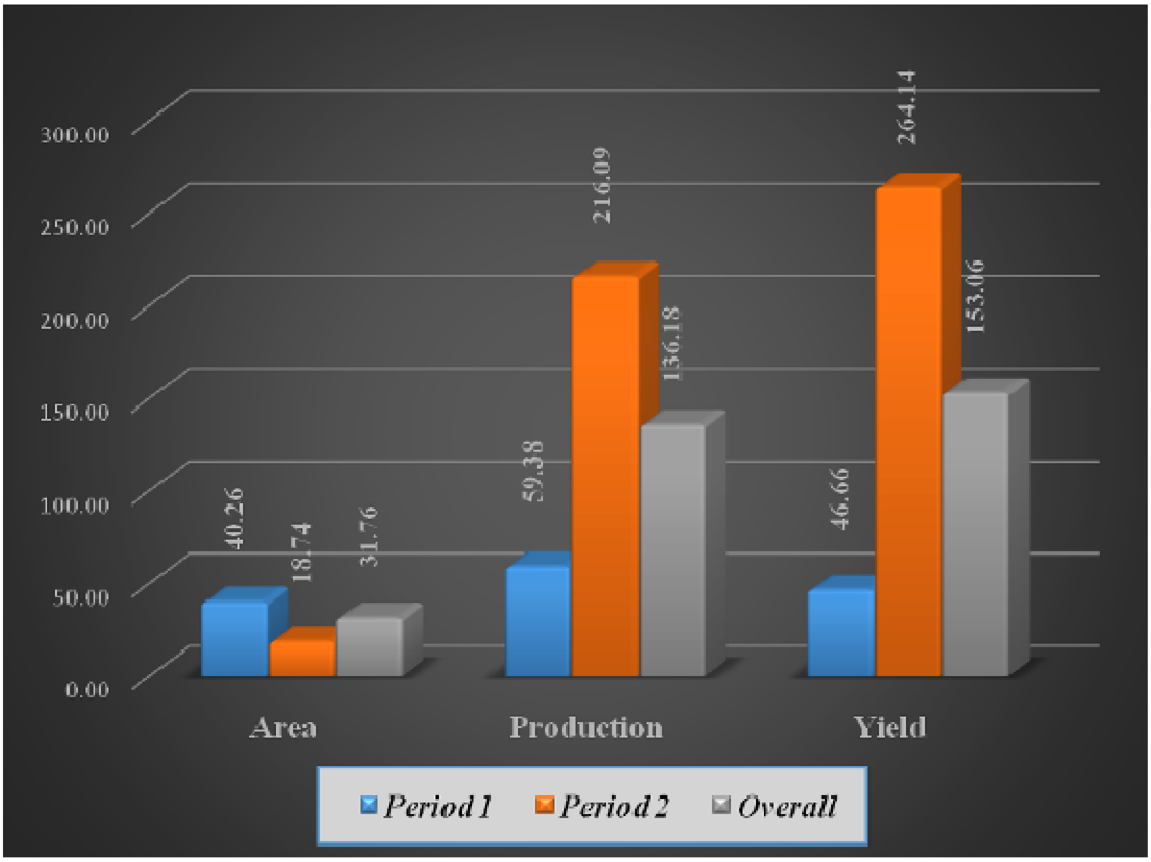


Fig. 4: Instability of Chickpea crops in Dharwad district

Table 4.2.2 Instability on area, production and yield of Cowpea crop in Dharwad district.

(Values in percentage)

	Area	Production	Yield
Period 1	30.79	**57.19**	**41.22**
Period2	21.04	25.96	22.01
Overall	27.13	29.80	24.42

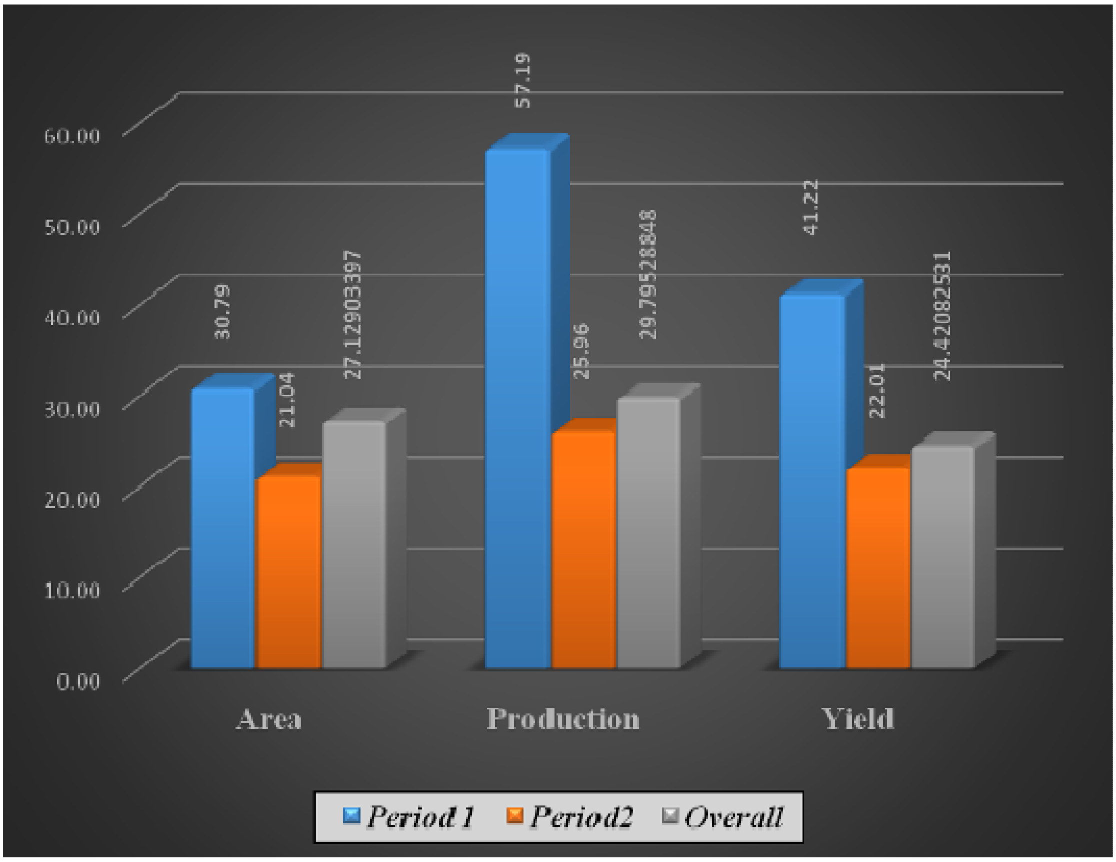


Fig. 5: Instability of Cowpea crops in Dharwad district

Table 4.3.1 Karl Pearson's Correlation between the production of Chickpea with area and weather parameters in Dharwad district.

Parameters	**Correlation Coefficients**
Area (ha)	0.43
Maximum temperature (^{0}C)	0.35
Minimum temperature (^{0}C)	**-0.45***
Relative humidity (percent)	0.30
Rainfall (mm)	0.39
*. Correlation is significant at 5 percent.	

Table 4.3.2 Impact of weather parameters and area on the production (in tonne) of Chickpea crop.

Parameters	Coefficients		|t|	Sig.	**R^2**
	B	Std. Error			
(Intercept)	-153715.34	88793.89	1.73	0.105	**0.718**
Area	0.35	0.18	1.98	0.067	
Max-T	**4596.48***	2013.60	2.28	**0.039**	
Min-T	-4448.02	2756.12	1.61	0.129	
Rh	**1277.78***	487.22	2.62	**0.020**	
Rf	**28.24****	8.89	3.18	**0.007**	
Dependent Variable: Production, ** significant at 1 percent, * significant at 5 percent					

From the Table 4.3.2 it is observed that, for production of Chickpea crop the multiple regression model was fit with R^2 =0.718. The results were found that the area, maximum temperature, relative humidity and rainfall were positively contributing to the production of Chickpea and the minimum temperature contributing negatively to the production of Chickpea crop. In that rainfall was significantly contributing at 1per cent as well as 5per cent level, while maximum temperature and relative humidity were significantly contributing at 5per cent level to the production of Chickpea crop. The R^2 value in multiple linear regression equation is higher which represents the contribution of area and weather parameters to the production of Chickpea crop is 71.8per cent. The multiple regression model for production of Chickpea crop obtained was,

Production(Y) = $-$ 153715.34 + 0.35X_1 + 4596.48*X_2 $-$ 4448.02 X_3 + 1277.78* X_4 + 28.24**X_5.

i.e. Production (Y) = $-$ 153715.34 + 0.35 (Area) + 4596.48* (Max-T) $-$ 4448.02 (Min-T) + 1277.78* (Relative humidity) + 28.24**(Rainfall)

In Table 4.3.3 it was noticed that, the correlation coefficient of area, relative humidity, minimum temperature and rain fall was positively correlated with production of Cowpea crop and the maximum temperature were showing negatively significant correlation with production of Chickpea crop.

The Table 4.3.4 revealed that for production of Cowpea crop the multiple regression model was fit with R^2 = 0.402. The result shows that the area, minimum temperature, relative humidity and rainfall were positively contributing to the production of Cowpea and the maximum temperature contributing negatively to the production of Cowpea crop. In that the maximum temperature was significant at 5per cent level and the R^2 value in multiple linear regression equation represents the contribution of area and weather parameters to the production of Cowpea crop is lesser which about 40.20per cent is. The multiple regression model for production of Cowpea crop obtained was,

Production (Y) = 721.73 + 0.05X_1 - 60.53*X_2 + 25.95X_3 + 8.02X_4 + 0.17X_5.

i.e. Production (Y) = 721.73 + 0.05(Area) $-$ 60.53*(Max-T) + 25.95(Min-T) + 8.02(Relative humidity) + 0.17(Rainfall).

Table 4.3.3 Karl Pearson's Correlation between the production of Cowpea with area and weather parameters in Dharwad district.

Parameters	Correlation Coefficients
Area (ha)	0.20
Maximum temperature (^{0}C)	**-0.43***
Minimum temperature (^{0}C)	0.25
Relative humidity (percent)	- 0.21
Rainfall (mm)	0.19

*. Correlation is significant at 5 percent.

Table 4.3.4 Impact of weather parameters and area on the production (in tonne) of Cowpea crop.

Parameters	Coefficients		|t|	Sig.	R^2
	B	Std. Error			
(Intercept)	-721.73	1030.18	0.70	0.494	**0.402**
Area	0.05	0.08	0.66	0.517	
Max-T	**-60.53***	25.70	2.36	**0.033**	
Min-T	25.95	33.60	0.77	0.452	
Rh	8.02	5.78	1.39	0.185	
Rf	0.17	0.12	1.43	0.174	

4.4 Development of decision support system

The Decision Support system has been developed in the MySQL database and in server type hardware and name of the webpage is given as "KRUSHIDHAMA". There are seven windows or section (Fig. 6) in the software which are discussed under following sub heading.

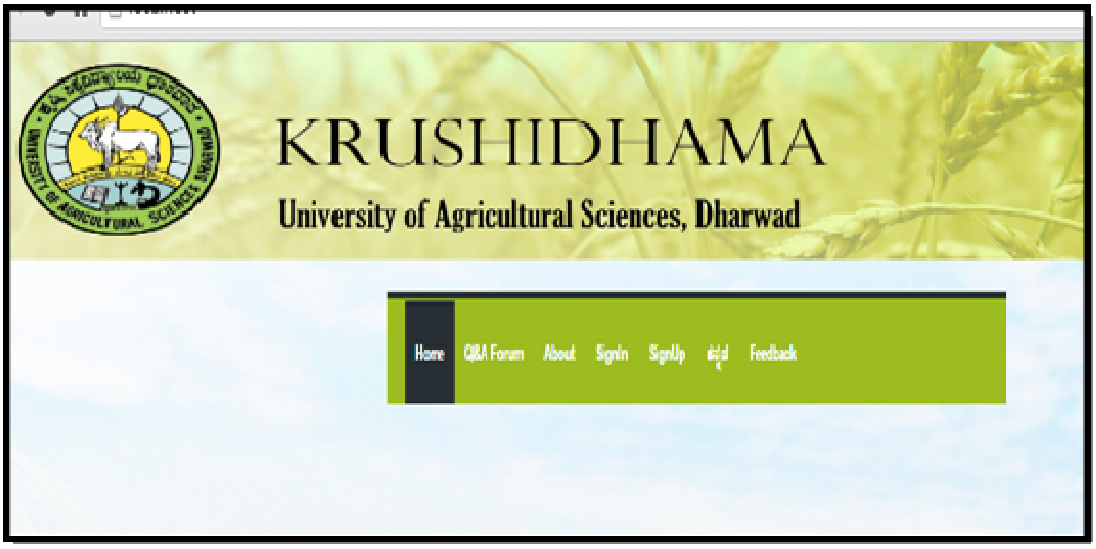


Fig. 6: Main Page

4.4.1 Home page window.

4.4.2 Q & A forum window.

4.4.3 About window.

4.4.4 Sign in window.

4.4.5 Sign up window.

4.4.6 Language selection window.

4.4.7 Feedback window.

4.4.1 Home page window

This home page window will display different crop categories *i.e.* pulses, cereals and commercial crops to be selected and other information window (Fig. 7).

Fig.7. Home page window

4.4.1.1 Crop selection window: In this window user has to select the crop of his interest by clicking on crop type as shown in Fig. 8. After selecting the crop it will directly take user to details information about that particular crop based on category named like origin, introduction, botany, seed and sowing, varieties, pests, weed and water management and harvesting.

Fig. 8: Crop selection window

4.4.1.2 Other information window: In this window website will display weather parameter selection window and area production selection window (Fig. 9)

Weather parameter selection window: Through this window user will be able to know about the situation of different weather parameters considered under study like Rainfall, Relative humidity, Maximum and Minimum temperature of particular crop selected under study by clicking on submit button after fill up the mandatory details.

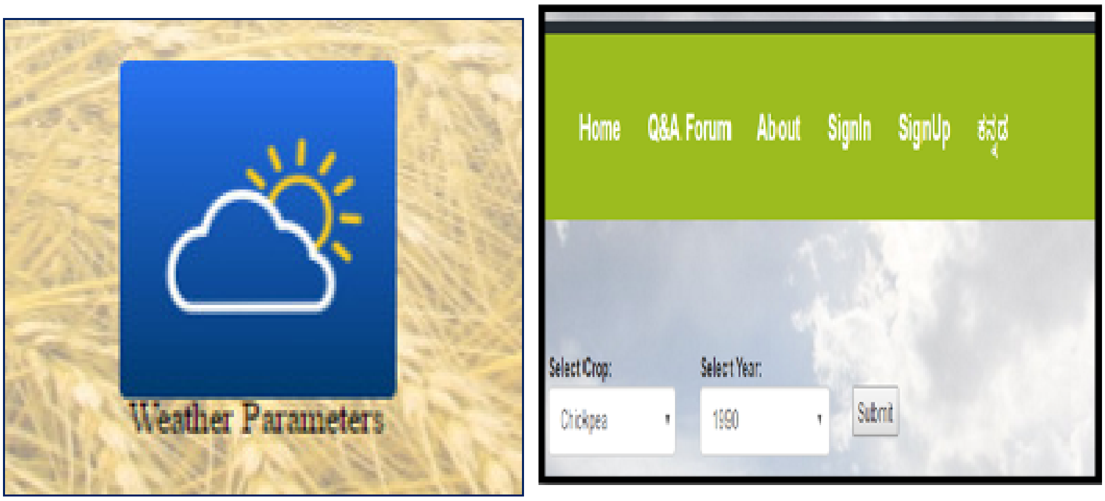


Fig. 9: Weather parameter selection window

Area and Production Selection Window: From this window (Fig. 10) user will be able to know about the situation of area as well as production of different crops considered under study by clicking on submit button after fill up the mandatory details.

Fig. 10: Area and Production Selection Window

4.4.2 Q & A forum: In this forum user will be able to query any problems regarding the crops.(Fig. 11).

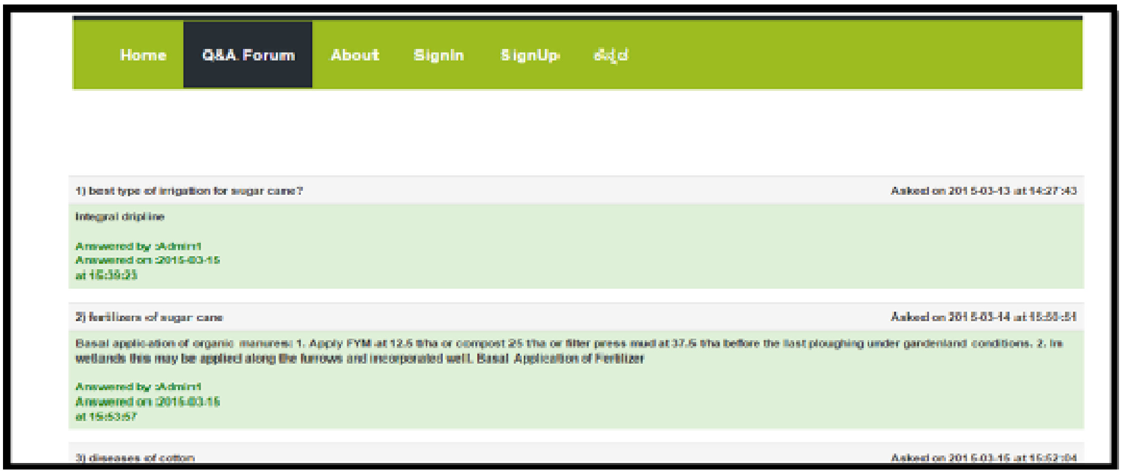


Fig. 11: Q & A forum Window

4.4.3 About window: This window will address about the software (Fig. 12).

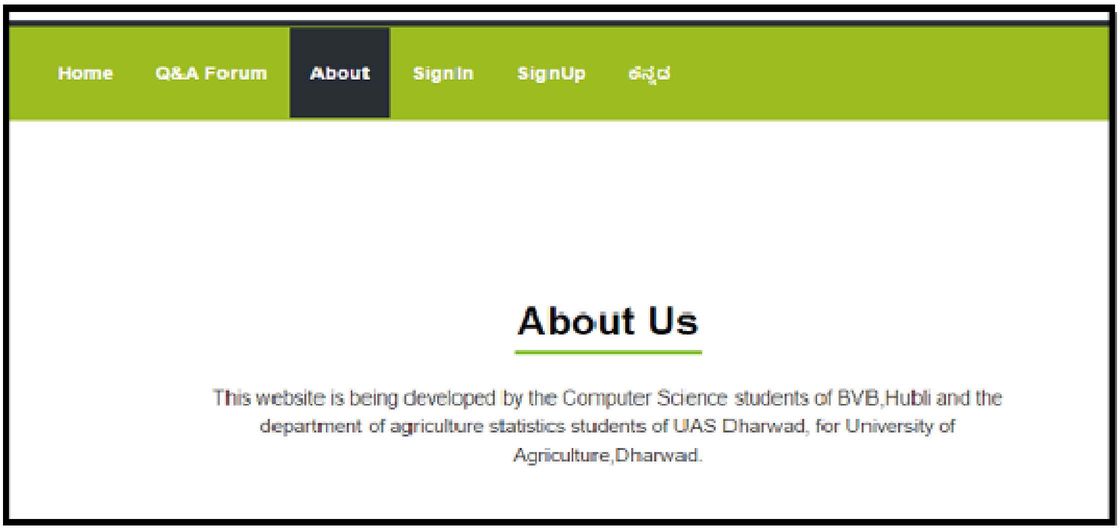


Fig. 12: About Window

4.4.4 Sign in window: In this window user has to enter the user name and password which is being same while registration (Fig. 13). This is require to ask question or to give feedback to the queries.

Fig. 13: Sign in window

4.4.5 Sign up window: In this window user has to enter the mandatory details for registration purpose then click on sign in (Fig. 14) which is require to ask question or to give feedback to the queries.

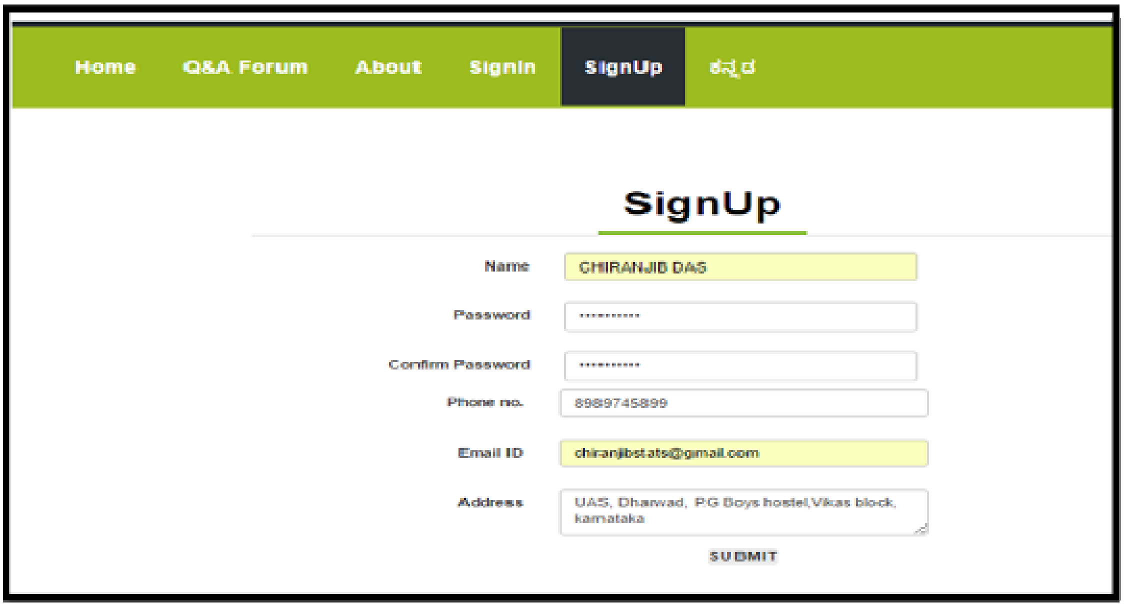


Fig. 14: Sign up window

4.4.6 Language selection window: In this window user has a facility to translate the webpage into Kannad or English language (Fig. 15)

Fig. 15: Language selection window

4.4.7 Feedback: In this window experts can give suggestion or feedback to the questions which has been asked. (Fig.16).

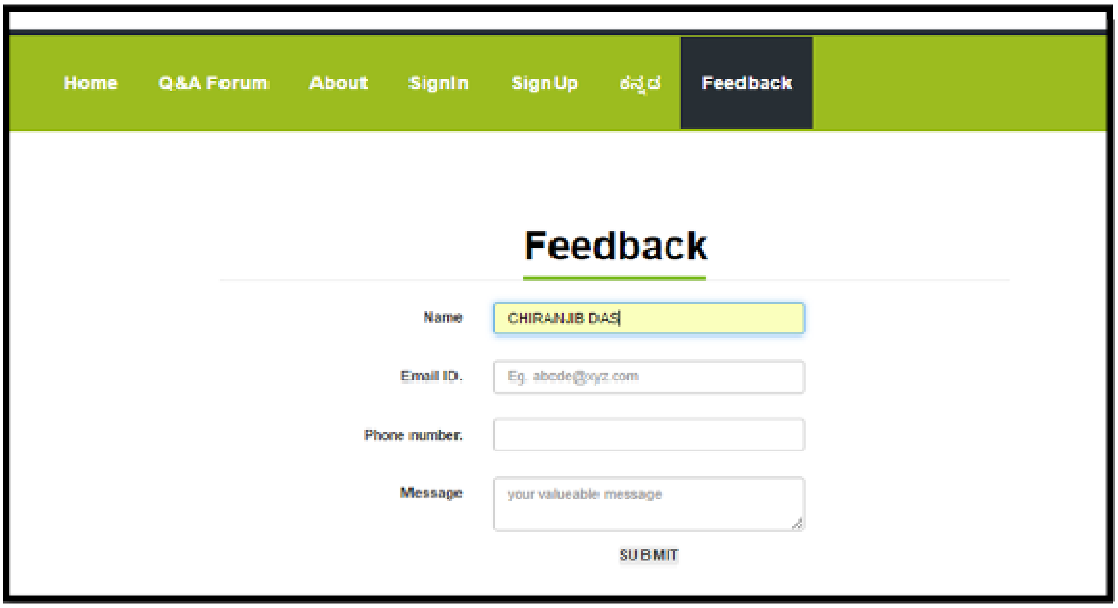


Fig. 16: Feedback window

5. DISCUSSION

The study was designed to develop Decision support system on selected pulse crops. Keeping the objectives and conceptual frame work of the study in view, the data was analyzed and the results are discussed under the following sections.

5.1 Transitional probability analysis (Markov chain analysis)

5.2 Instability analysis of selected pulse crops

5.3 Multiple regression analysis

5.4 Decision support system

5.1 Transitional probability analysis (Markov chain analysis)

The shift of area of major pulse crops in Dharwad district was obtained from the transitional probability matrix by applying Markov chain analysis. The transitional probabilities are presented in matrix form in table 4.1.1 and depicted a wide concept about shift in area over a period of twenty years from 1990-1991 to 2009-2010. Five pulse crops like Chickpea, Cowpea, Arhar / Tur, Horse gram and Green gram / Moong were selected for analysis purpose. The diagonal elements in the transitional probability matrix provide the information on the probability of retention of area of corresponding crop, the row elements show the probability of loss in area *i.e.* shift in area from one crop to other crops and the column elements indicate the probability of gain in area from other crops to particular crop.

This result was supported with the findings of Savadatti (2006) who employed Markov chain model to analyse the direction and changing pattern of export of Basmati rice for the period 1980-81 to 2000-02.

In the present study it is revealed from the result shown in the Table 4.1.1, that the highest retention of area was identified in case of chickpea crop (73.24 per cent) followed by green gram (70.24 per cent), horse gram and no retention was found in case of cowpea crop (0.00 per cent) and arhar crop (0.00 per cent). To hold their shift in area, chickpea crop has gained area at about 91.61 per cent form arhar crop, 54.86 per cent from horse gram and 25.57 per cent from green gram crop. At the same time chickpea crop losts 1.33 per cent area to cowpea, 5.35 per cent to arhar, 4.51 per cent to horse gram and 15.57 per cent to green gram crop. Cowpea crop has gained area of 1.33 per cent from chickpea crop, 3.03 per cent from horse gram and 1.82 per cent from green gram and at the same time it has lost its 100 per cent to green gram crop. In case of arhar crop, it has gained area of 5.35 per cent from chickpea and 2.37 per cent from green gram crop and at the same time it has lost its area to chickpea crop at 91.61 per cent which is quite higher and 8.39 per cent to horse gram. Horse gram crop has gained area at 4.51 per cent from chickpea and 8.39 per cent from arhar and it has lost its area to 54.86 per cent to chickpea crop and 3.03 per cent to cowpea crop. While green gram has gained much to the extent of 100.00 per cent from cowpea and 15.57 per cent from chickpea crop. Overall it is observed that retention in area for chickpea and green gram crop was almost nearer to each other.

This result is supported with the results obtained by Suresh (2013) who applied Markov chain model to study the impact of weather parameters on the production of rainfed crops of Dharwad district and found that the retention of area was almost similar ranging from 38per cent to 44per cent in all area of rain fed crops in Dharwad taluk.

This result is also supported with the findings of Ashalatha (2004) who used the Markov chain analysis to analyse the probability retention in cashew during the year 1995-96 to 2002- 03 and observed that the stable importers of Indian Cashew kernel with high probability of retention were USA and Netherlands while Australia was moderately stable importer, and the unstable importer was noticed were UK, Japan, UAE and Singapore. Even though the other importers like UK, Japan, UAE, Singapore and Australia are probable to increase their share at the cost of USA and other countries the USA and Netherlands will continue to be the major importers of cashew kernel from India in future.

5.2 Instability analysis of selected pulse crops

To study the area, production and yield instability, Coppock's instability index was carried out to estimate and compare the variability in areas, productions and yields during the successive time periods. For this objective secondary data was collected for 20 years from 1990-1991 to 2009-2010 on area, production and yield of selected pulse crops *i.e.* Chickpea and Cowpea. For this objective whole data was divided into two sub periods *i.e.* period I (1990-1991 to 1999-2000) and period II (2000-2001 to 2009-2010) and overall also has been analysed. The result observed after analyzing are discussed below.

In case of Chickpea result revealed that overall instability was higher in yield than area and production. Overall contribution of yield for instability of production is higher than area. Whereas in period I the instability is lower in the case of yield than production but higher than area. Here also in period I contribution of yield for instability of production is higher than area. In case of period II again instability was found to be higher in yield than area and production. Because in period II Production suddenly decrease in 2001-02 and in 2003-04. Here contribution of yield is noticed to be more than area for instability to the production. But production and yield was highly instable throughout periods under the study in Dharwad district. These indicates that as compare to area, production and yield under the chickpea crop is highly instable among the 20 years of period which result in low productivity to the chickpea growing farmer.

Similarly in case of Cowpea the result depicted that overall instability was higher in production than area and yield. Overall contribution of area for instability of production was found to be higher than yield. Similarly in period I the instability is noticed to be higher in the case of production than yield and area. Here in period I contribution of yield for instability of production is observed to be higher than area. In case of period II again instability was higher in production than area and yield. Here contribution of yield is found to be more than area for instability to the production. But production is slightly instable throughout periods under the study in Dharwad district. These indicates that as compare to area, production and yield under the cowpea crop is slightly instable among the 20 years of period which result in low productivity at small extent to the cowpea growing farmer. But It can be observed that instability in area, production and yield of Cowpea crop is decreased in Period II compare to Period I which is quite good.

The present study is supported by Amarender and Devraj (2006) who conducted a research study on "Growth and instability in Chickpea production in India: A state level analysis" and observed that overall instability was higher in production than area and yield at all India level. Instability was higher in second period than first period. Instability in yield was higher than area and it was contributing more to the production instability in both the periods. Instability of yield was increased and area was decreased in the second period compared to first period. However in some states like Tamil Nadu, Rajasthan, Haryana and Gujarat instability was higher than yield instability.

Similar study was conducted by Shaikh and Joshi (2013) who carried a research on “Analysis of instability and growth rate of cotton in three district of Marathwada” in Maharashtra. They observed that overall instability was higher in case of production than area and yield at all there three districts. Whereas the instability was lower in case of area specially Jalna district followed by Aurangabad and Beed. But Production and yield was highly instable throughout the periods among all three districts. These indicates that as compare to area, production and yield under the cotton crop was highly instable among the 30 years of period which result in low productivity to the cotton growing farmer.

5.3 Multiple regression analysis

To examine the functional relationship of several independent variables with dependent variable multiple regression analysis was applied. In the present investigation impact of weather parameters and area on production of selected pulse crops was analysed.

An attempt to estimate the contribution of area and weather parameters like maximum temperature, minimum temperature, relative humidity and rainfall on the production of Chickpea and Cowpea crop was made and the results were given under chapter 4. *i.e.* Results and are discussed below.

It has been observed that out of five parameters like area, maximum temperature, minimum temperature, relative humidity and rainfall only minimum temperature contributing negatively to the production of Chickpea crop and area, maximum temperature, relative humidity and rainfall were positively contributing to the production of Chickpea crops in case of Dharwad district and it was also found that rainfall was significantly contributing at 1per cent as well as 5per cent level, while maximum temperature and relative humidity were significantly contributing at 5per cent level to the production of Chickpea crop. In multiple linear regression equation R^2 value is significant and higher which represents true relationship between productions of Chickpea crops, area and weather parameter. .

Similar work has been done by Suresh (2013) conducted a research on multivariate analysis to study the impact of weather parameters on rain fed crops of Dharwad district. For this purpose researcher applied Multiple linear regressions indicated that only area and rainfall were contributing significantly to the production of rain fed crops, but relative humidity was also contributing significantly to the production of Paddy crop in case of Dharwad taluk.

Similarly for Cowpea crop the independent variables *i.e.* area, maximum temperature, minimum temperature, relative humidity and rainfall were employed simultaneously for predicting the production of Cowpea. Result shows that the area, minimum temperature, relative humidity and Rain fall were positively contributing to the production of Cowpea and the maximum temperature contributing negatively to the production of Cowpea crop. In that the maximum temperature was significant at 5per cent level and the R^2 value in multiple linear regression equation represents the contribution of area and weather parameters to the production of Cowpea crop is lesser.

Similar work has been done by Mokashi *et al.* (2008). Their experiment was carried out for five years on sunflower by using four different sowing windows to study the relationship between weather parameters and yield in Rabi season during the rainy season from 1999 to 2004 at Dry farming Research Station, Solapur. The minimum temperature had highly significant positive association with grain yield at all the phonological phases. Relative humidity had significant positive association with grain yield at 4th leaf to 50 per cent flowering stage. Bright sunshine had significant positive association with grain yield. Significant negative association with grain yield by pan evaporation indicates that at early growth

Another similar work has been done by Bandopadhyay in 2006, who used multiple linear regression to predict the average-monsoon rainfall using the previous year's data from the corresponding time period. The overall prediction error was found out to be 24.46 per cent and t-values were found non-significant indicating that, none of the months was a good predictor of average monsoon rainfall.

5.4 Decision support system

For the particular objective a website design has been developed for UASD (University Of Agricultural Sciences, Dharwad) with the help of students of Department of computer science, cells of BVB Engineering and technology, Hubli, collected the functional and non-functional requirements that needed to be achieved. The website is developed in MySQL open source database. This website is designated based on the details about the selected crops, origin, introduction, botany, soil, climate, seed and sowing, varieties, pests, diseases, weed management, water management, harvesting, area and production and weather parameters. For designing this website a document is prepared called SRS (Software Requirement System) which contains functional and non-functional requirements. Name of the webpage was given as "KRUSHIDHAMA". There are seven windows or section in the software which are discussed under following sub heading.

5.4.1 Home page window.
5.4.2 Q & A forum window.
5.4.3 About window.
5.4.4 Sign in window.
5.4.5 Sign up window.
5.4.6 Language selection window.
5.4.7 Feedback window.

5.4.1 Home page window

This home page window will display different crop categories *i.e.* pulses, cereals and commercial crops to be selected and other information window.

5.4.2 Q & A forum: In this forum user will be able to query any problems regarding the crops.

5.4.3 About window: This window will address about the software

5.4.4 Sign in window: In this window user has to enter the user name and password which is being same while registration. This is require to ask question or to give feedback to the queries

5.4.5 Sign up window: In this window user has to enter the mandatory details for registration purpose then click on sign in which is require to ask question or to give feedback to the queries.

5.4.6 Language selection window: In this window user has a facility to translate the webpage into Kannad or English language.

5.4.7 Feedback: In this window experts can give suggestion or feedback to the questions which has been asked.

This study also supported by Ashalatha (2009) who developed a system entitled “Development of Database management and statistical analysis through specially designed software”. Researcher has created a database system on important crops which would provide information with respect to its scientific name, image, area, production and productivity, varieties grown under different season under irrigated as well as rainfed.

Similar study was conducted by Daniel (2011) who developed “Crop nutrient management decision support system” for black gram and paddy in Tamil Nadu. He used the site specific nutrient management as the base for the system and the system was developed in visual basic.

A harmonious study was conducted by Vishwajith (2012) who conducted a research on “Development of Decision Support System for Fertilizer Recommendation for Selected Zones of Karnataka”. He applied site specifically to estimate yield of selected crops in response to fertilizer recommendation for the selected zones in Karnataka.

A similar study was conducted by Gurupadappa (2014) who developed a system named “Development of Decision Support System for Cotton and Sugarcane” in Dharwad. He used the site to estimate yield of selected crops in response to disease, pest and weed growth and the system was developed in visual basic.

6. SUMMARY AND CONCLUSIONS

Agriculture continues to remain the major sector of Indian economy even after independence. Despite the development of software tools at the research centres, transferring of technologies developed required personal communication to farmers and agricultural extension workers at villages. Furthermore, the adoption of these tools remained as a challenge. Low adoption of decision support in agriculture system requires developing improved approaches of DSS development. In addition, the approaches for developing decision support system should consider participation of key users.

Computer algorithms have been used in agriculture and allied fields for over thirty years. Areas of usages dealt from computing to the existing multitude of uses in agricultural research such as monitoring, evaluation and control, information management and dissemination, teaching, training and decision support systems. The use of computer algorithms has brought awareness and the potentialities of different disciplines due to possibility of storing and transmitting information. We need to revamp and revitalize the education service in such a way that it reaches to the farmers / field level workers more effectively. The development of "Decision support system for cowpea and chickpea crops" is an effort in this direction.

According to Directorate of Economics and Statistics in last two –three years though area increased in case of chickpea, production and yield get decreased, While area decreased in case of cowpea and yield and production also decreased. In order to increase production of pulse crops (cowpea and chickpea) and to make long sighted, allowable and appropriate decisions, farmers need timely, reputable, compatible or correlative access to take advice on agricultural problems from experts.

The present study gives the information pertaining to the origin, introduction, botany, seed and sowing, varieties, pests, disease, weed and water management and harvesting of Cowpea and Chickpea crops as well as relationship between weather parameters and area with the production of selected pulse crops considered under study. Data were collected from different secondary sources. This study also gives the information about shift in area among selected major pulse crops considered for the specific objective in Dharwad district which helps to take the perfect decisions on shifting area of a particular crop to other crop as well as this study helps to know the instability in area, production and yield of Cowpea and Chickpea crops throughout the period and gives an idea to take proper decision about the crops. The present study was taken up in Dharwad district of Karnataka state with the following objectives

Specific objectives of the study

1. To identify the direction of structural change in the area of selected pulse crops to other pulse crops in Dharwad district
2. To study the instability in area, production and yield of selected pulse crops
3. To study the impact of weather parameters on the production of selected pulse crops
4. To develop decision support system for the selected pulse crops.

6.1 Material and methods

Keeping in view the objectives of the study secondary data were collected from different sources, they are Karnataka at A glance: Government of Karnataka, District statistical office Dharwad, Directorate of economics and statistics Bangalore, Main Agricultural Research Station, Dharwad, and http://www.indiastat.com. The package of practice for Cowpea and Chickpea were collected from university of Agriculture College, Dharwad and TNAU Agritech. Portal and internet.

Researchable data contains information on weather parameters like, maximum temperature, minimum temperature, relative humidity and rainfall from 1990-2009 and area, production and yield data of selected pulse crops in Dharwad district was collected from 1990-1991 to 2009-2010. The twenty years data were used for the study of selected pulse crops *i.e.* Cowpea and Chickpea in the Dharwad district.

The method of Markov chain analysis, Coppock's instability analysis, correlation and Multiple regression analysis, were adopted to reach the objectives *i.e.* To identify the direction of structural change in the area of selected pulse crops to other pulse crops in Dharwad district, to study the instability of selected pulse crops, to study the impact of weather parameters on the production of pulse crops and to develop decision support system for pulse crops (Cowpea, Chickpea).

6.2 Major findings of the study are as follows

- The Shifts of area of pulse crops in Dharwad district was estimated by applying Markov chain analysis. Main frame of this analysis is the transitional probability matrix which depicted a broader idea in the direction of structural change of area over a period of twenty years. Five major pulse crops like Chickpea, Cowpea, Arhar, Horse gram and Green gram were selected in Dharwad district. The result revealed that the retention of area was almost similar for Chickpea and Green gram ranging from 70per cent to 73per cent in Dharwad and for Horse gram it was found to be 42per cent. The highest retention of area was noticed in Chickpea crop (73.24per cent) and lowest retention of area was noticed in Cowpea and Arhar (00.00per cent) respectively

- To know the instability of selected pulse crops in Dharwad district Coppock's instability analysis was carried out. The data was collected of twenty years from 1990-1991 to 2009-2010 and the data was divided into two sub-periods *i.e.* period I (1990-1991 to 1999-2000) and period II (2000-2001 to 2009-2010) and overall period. The result revealed that instability was higher in case of Chickpea crop than Cowpea crop in Period II with respect to production and yield. Overall instability was higher in case of Chickpea than Cowpea. In case of Chickpea instability was higher in production than yield and area in period I. In period II and overall instability was higher in yield than production. Whereas in case of Cowpea overall instability in production was higher than area and yield. Throughout the periods instability was quite higher in production of Cowpea.

- In case of multiple regression analysis independent variables were applied simultaneously to know the influence of on production of selected pulse crops *i.e.* Cowpea and Chickpea. Out of five parameters viz., area, maximum temperature, minimum temperature, relative humidity and rainfall only minimum temperature contributing negatively to the production of Chickpea crop and area, maximum temperature, relative humidity and rainfall were positively contributing to the production of Chickpea crops, where later three parameters are contributing significantly. Area, minimum temperature, relative humidity and rainfall were positively contributing to the production of Cowpea and the maximum temperature contributing significantly negatively to the production of Cowpea crop.

- For the development of decision support system, MySQL database source was used. The main page was named as “KRUSHIDHAMA”. This website includes: a) Home page window, b) Q&A forum window, c) About Us window, d) Sign in window, e) Sign up window, f) Feedback window, g) Language translation window. This developed software is very useful not only to the farmers but also to the scientists, researchers, innovators, agricultural workers and policy makers to aware about the situation of selected pulse crops in Dharwad district. Farmers who are little aware of computer can ask the queries regarding crops and get suggestion from experts which can help for increasing crop production. This website gives details in Kannada also, which will help the persons who has little basic knowledge about internet and computer.

6.3 Future line of work

Following future line is suggested based on the findings generated by the present study

1. The present study can be expanded for all the districts across the state to identify the direction of structural change in area of pulse crops to other crops and also future movement or shifting behaviour of the crops based on the transitional probability matrix.
2. To know the instability of pulse crops, the similar study can be extended to all the districts across the state. Through this, policy makers will get the information about the instability of crops and may take a serious measure about the crops.
3. Similar study can be adopted to know the impact of weather parameters on the production or yield of other crops can be spread to all the districts across the state and country so that by taking proper management, production can be increased of different crops.
4. This DSS can be extended to all other major crops, globally
5. This DSS can be further extended with method of application of fertilizers and other package of practices of different crops.
6. DSS can help the farmers, scientists, young researchers, innovators and policy maker for implementation of innovative and technological programme.
7. Users can update this system software and dynamic web portal can be developed.

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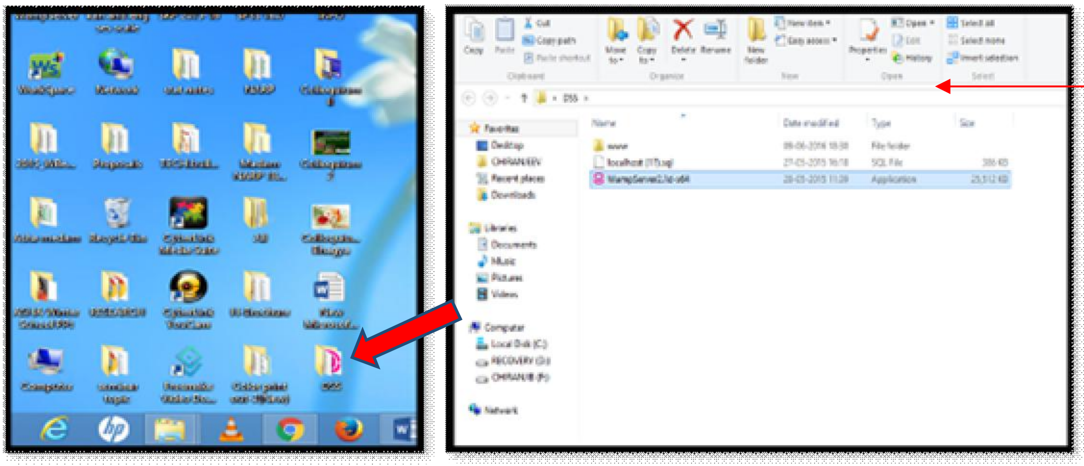
APPENDIX-I

Procedure to install the DSS software

1. Copy the Web Portal folder from the given CD to Desktop.

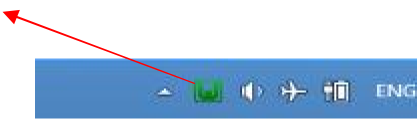
2. First install the '**WampServer2.1d-x64**'application into C-drive.

- A Wamp folder will created in the C drive and a shortcut file wamp server will create on desktop.
- Copy the 'www' file and the localhost (17) into the wamp folder from the desktop (Web portal folder).

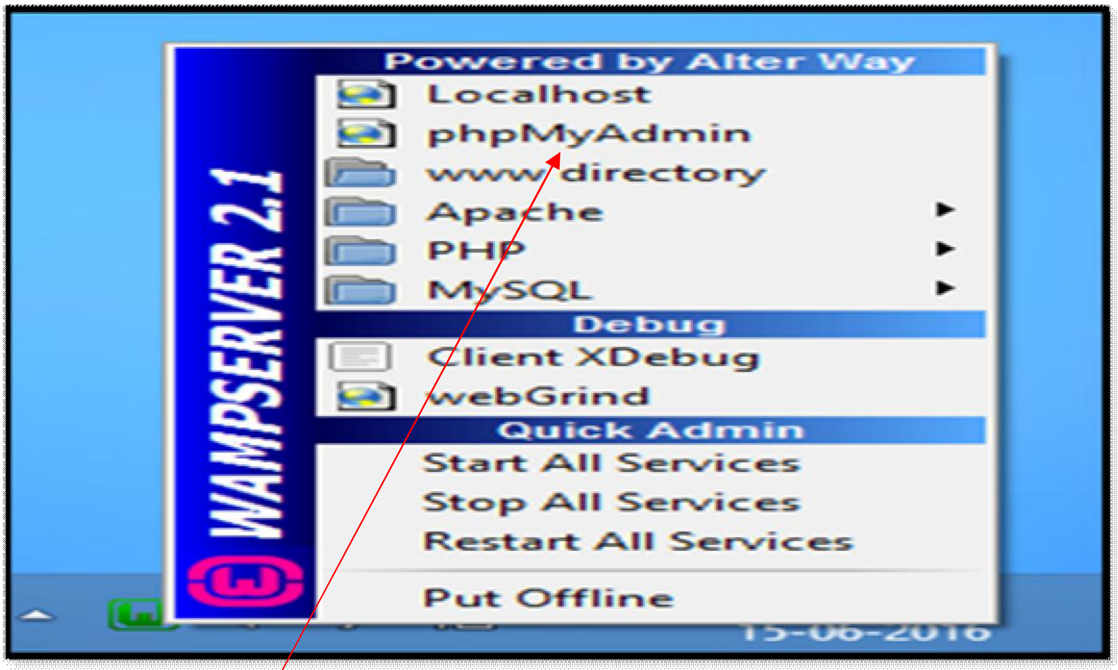


3. Click the **wamp server** shortcut file on Desktop.

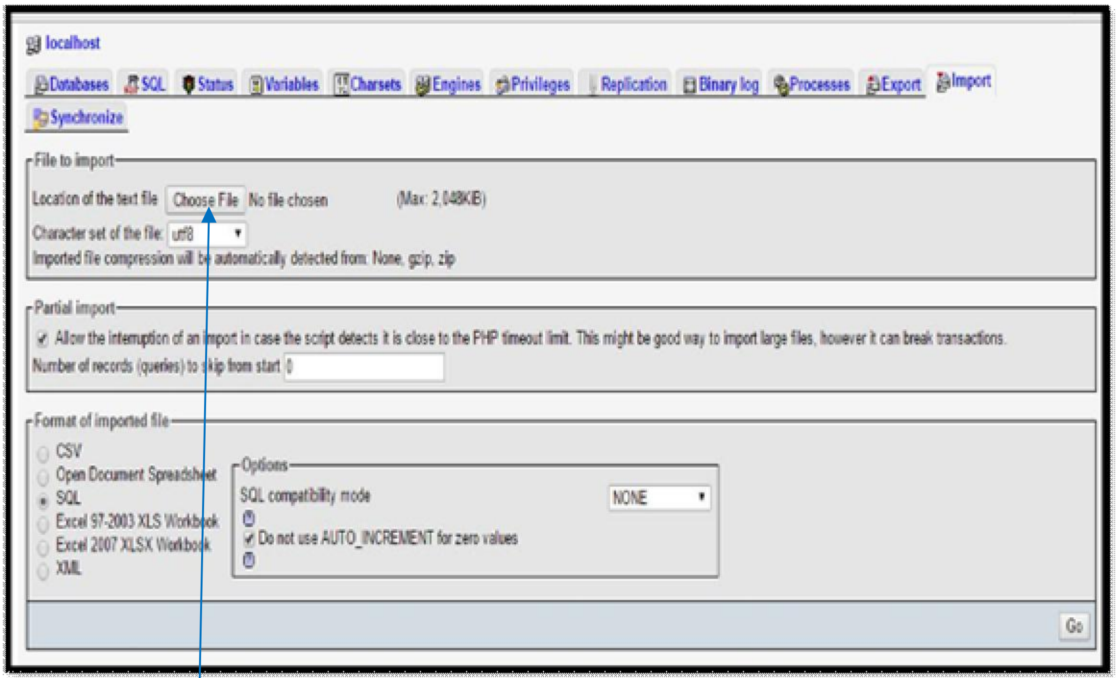
Then click on “Yes” .Wampserver will open on the taskbar, click on that wampserver symbol. Wamp server will open with green colour if that is in red colour put wampserver on online mode then it will turn to green



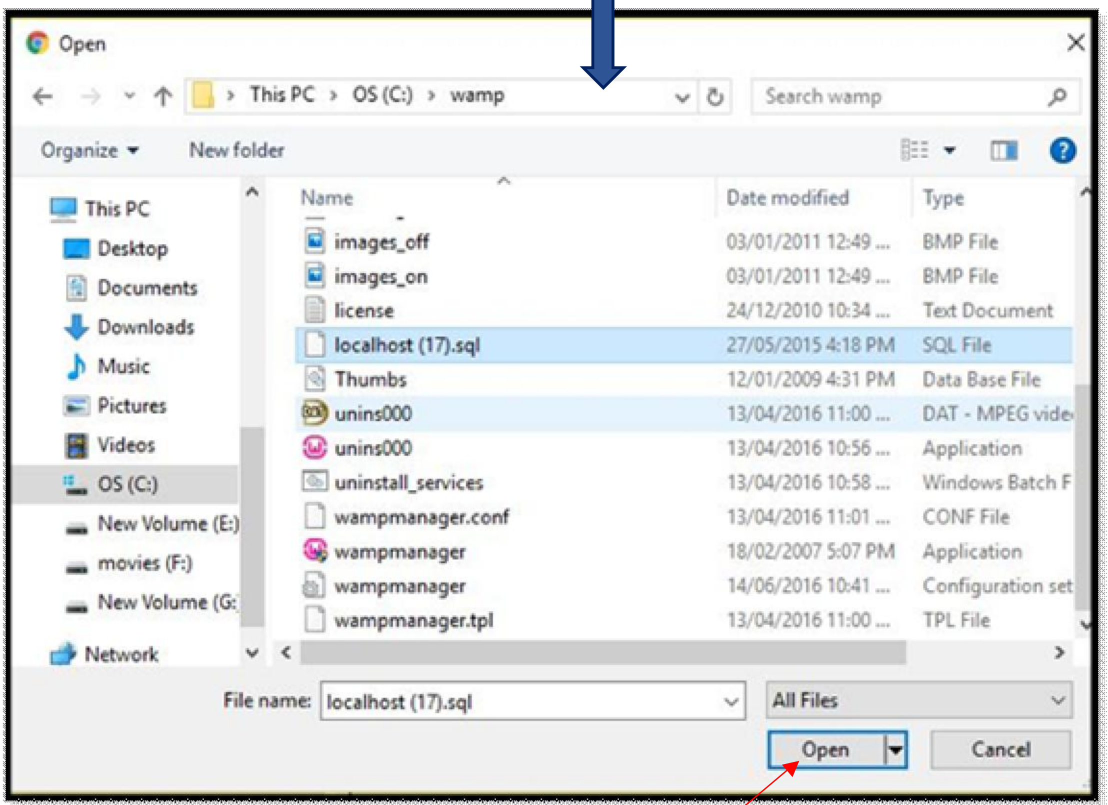
.



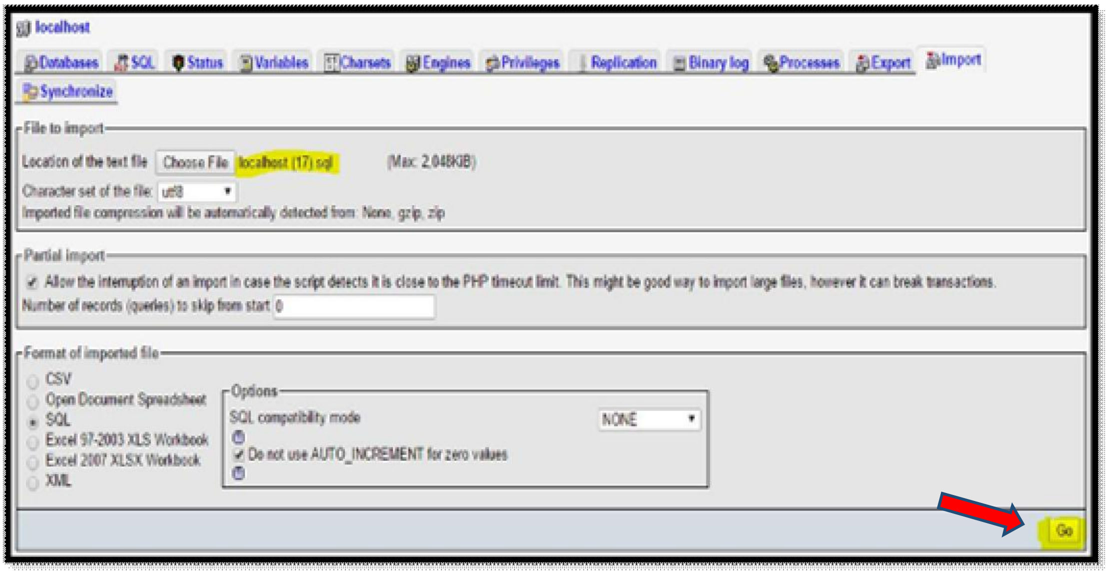
Click on “phpMyadmin” localhost php file will open. Which helps add the test *i.e.* information about crops in localhost “KRUSHIDHAMA”.



Click on "Choose file" select the localhost from the wamp folder which is in the C drive of the PC.



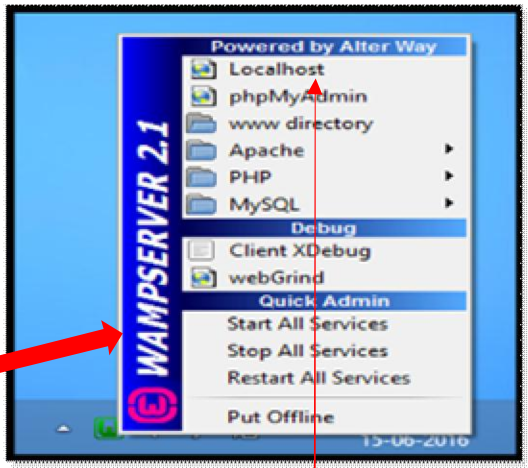
Select the "**localhost (17).sql**" and click on **open** which helps to open the KRUSHIDHAMA in the web page. After clicking in open dialog box will appear as shown below:



Click on “**GO** “option to add the ‘**localhost (17).sql**’ file to phpMyadmin page.

Know that the “**test**” file will inserted to phpMyadmin, after inserted test file close the phpMyadmin.

4. Open the “wampserver”



Click on “localhost”.

Home page of “KRUSHIDHAMA” will open.

This page will display the detailed information about agricultural crops, weather parameters, area and production.

Once we click on “**Pulses**” dialog box will appear as shown below:

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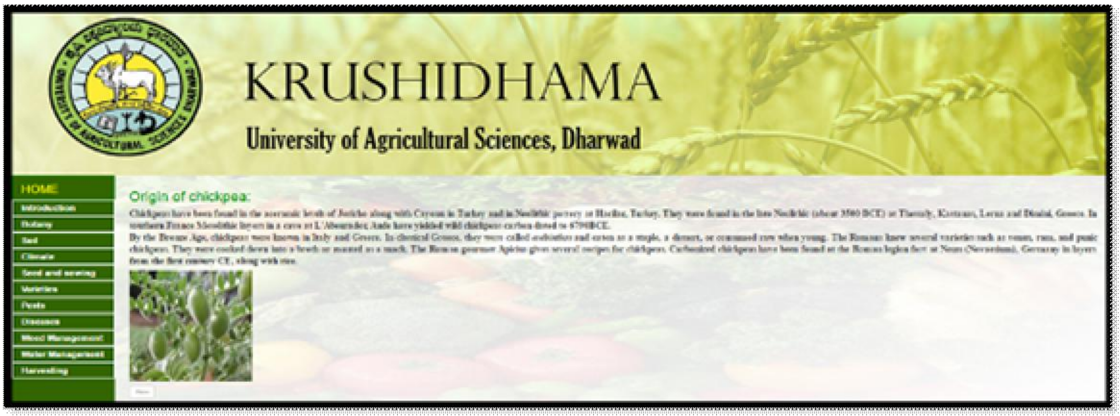
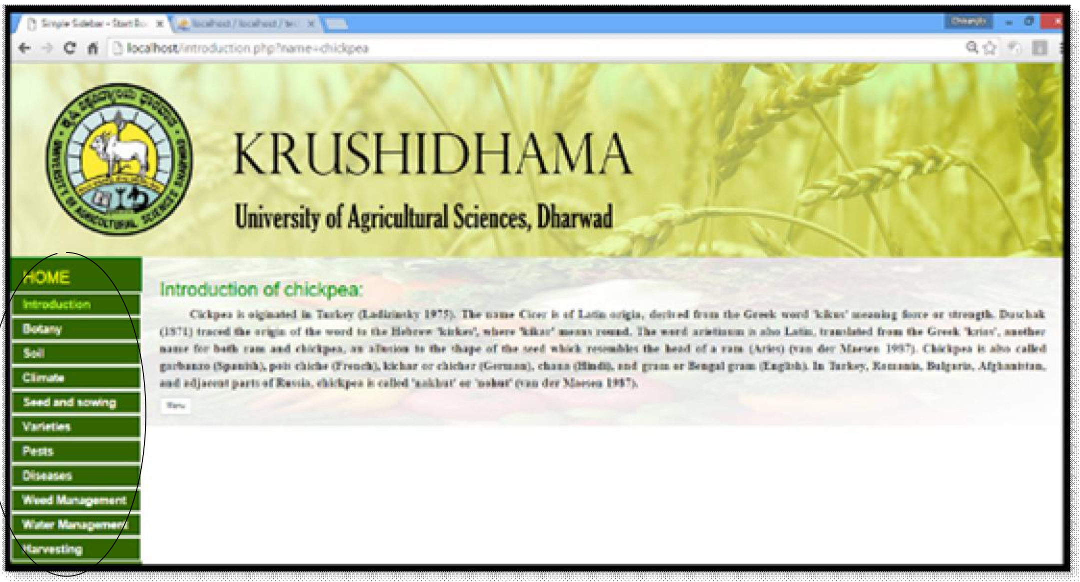
o.

Ex: Click on “**Chickpea**” crop.



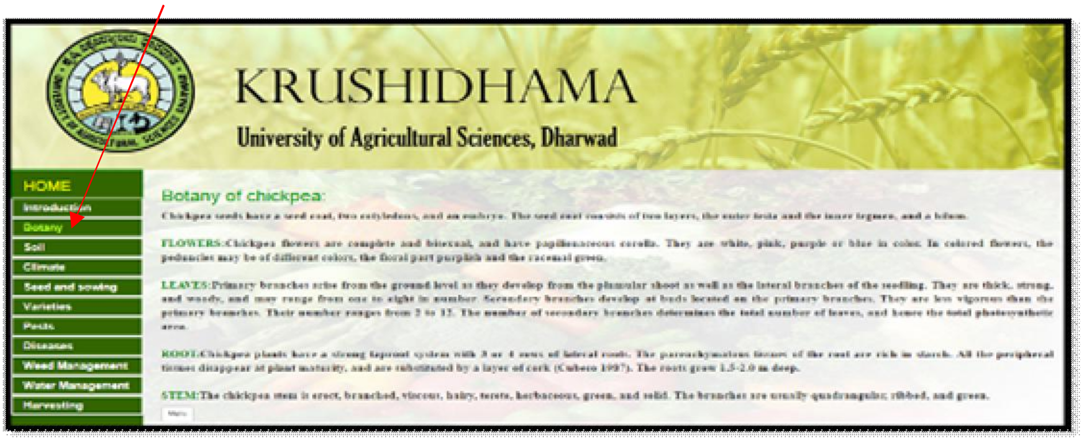
By clicking on Chickpea crop user will get the information like Introduction, Botany, Soil, Climate, Seed and sowing, Varieties, Pests, Disease, Weed management, Water management and Harvesting.

Click on ‘**Introduction**’ then we will get the ‘**Introduction about Chickpea**’



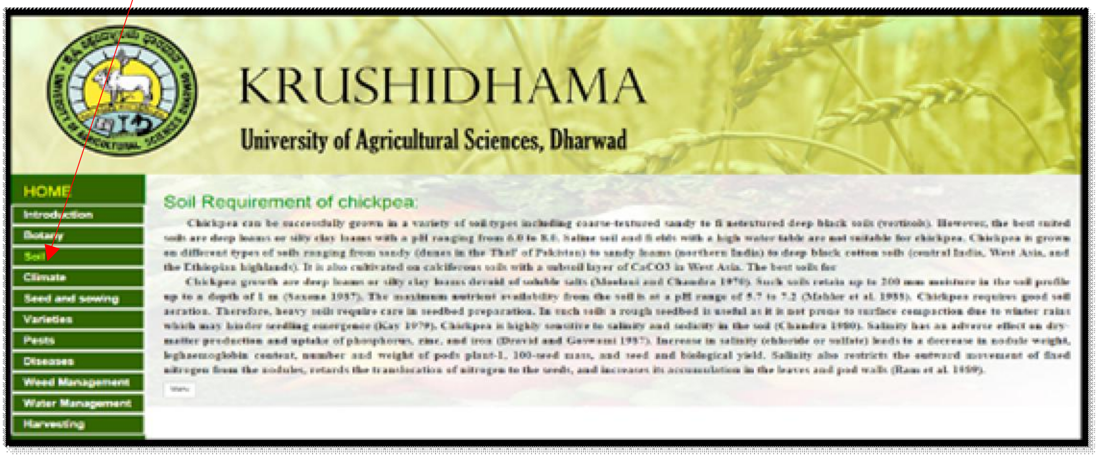
Similarly

Click on ‘**Botany’**



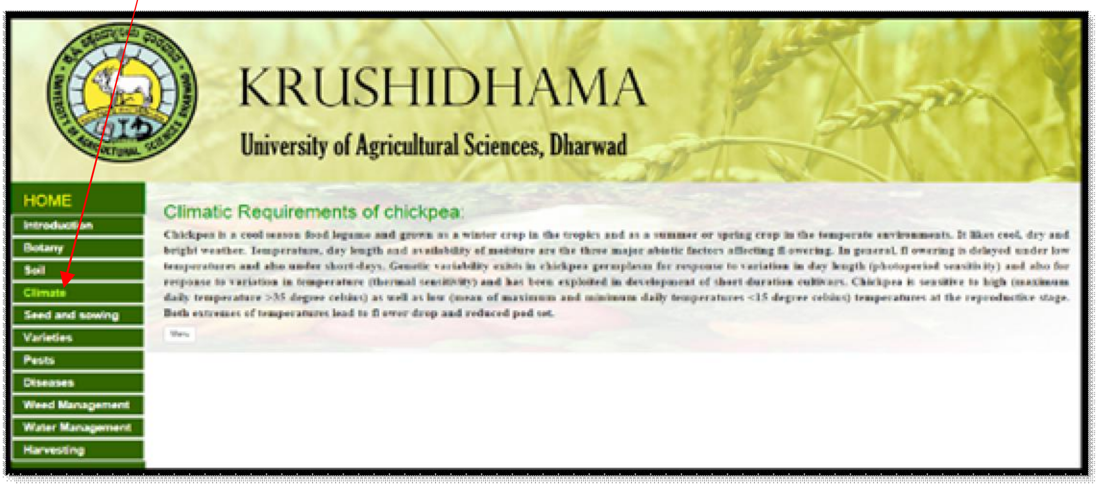
Click on ‘**Soil’**

Which contains the information about soil and P^{H} requirement for the crop.



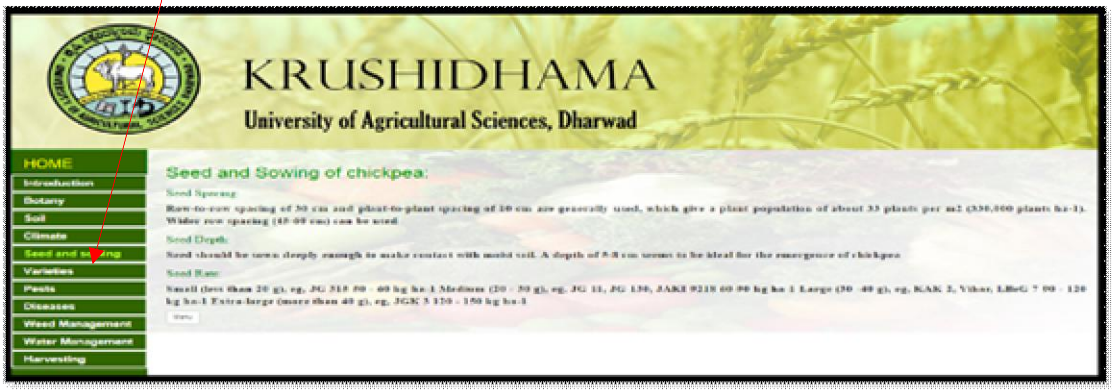
Click on ‘**Climate’**

Which helps to know the climate required for growing the Chickpea crop



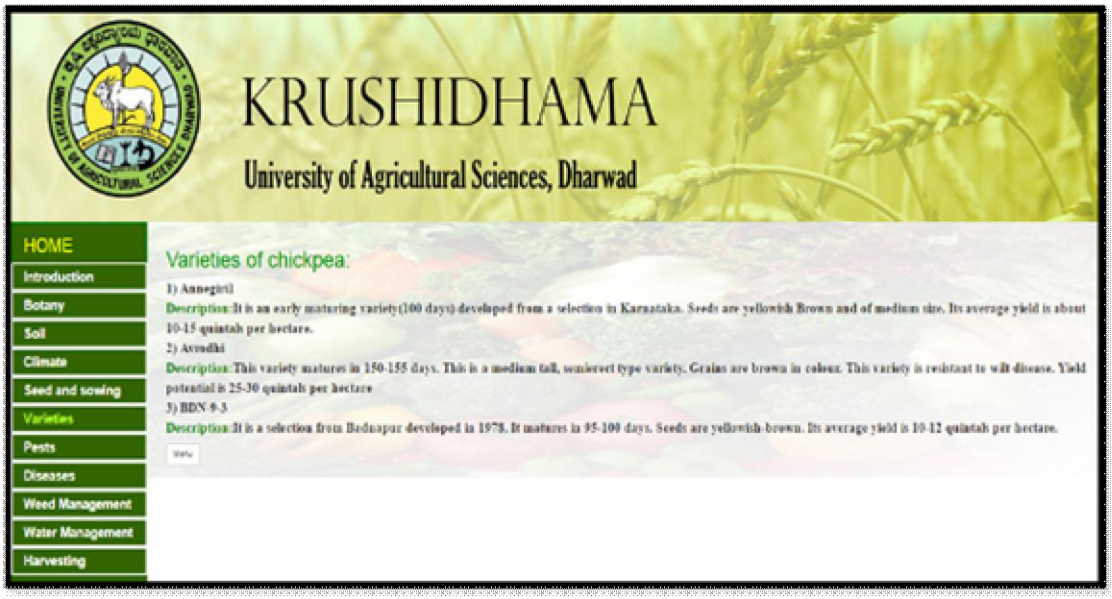
Click on '**Seed and sowing'**

Which helps to know about the seed and sowing method for the Chickpea



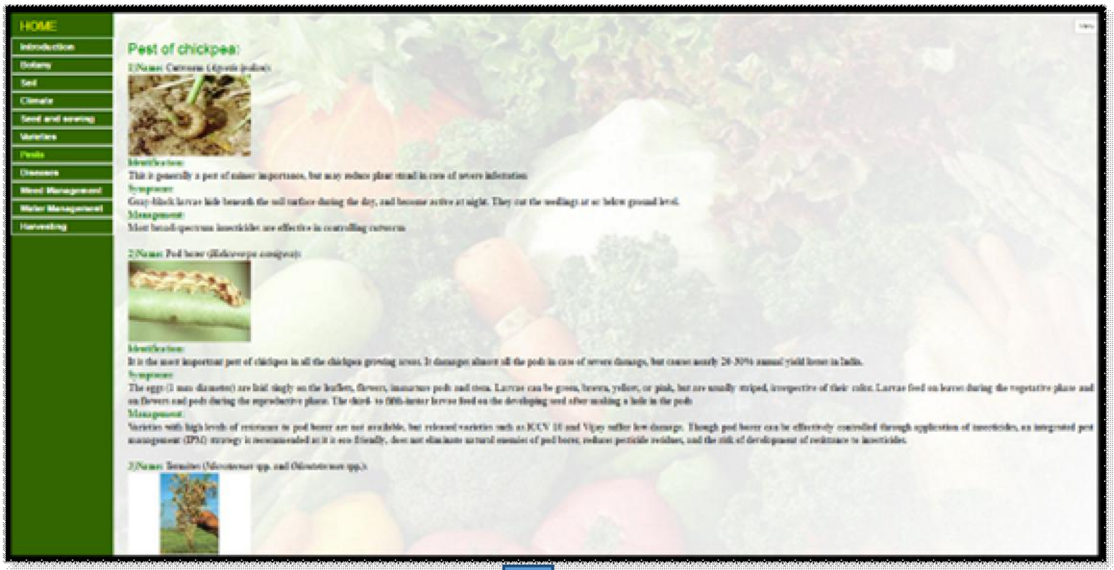
Click on '**Varieties'**

Which helps to know about the growing as well as resistant varieties for Chickpea crop.



Click on **'pests'**

Which will helps to know about different pests of Chickpea and controlling measures for those particular pests of Chickpea.

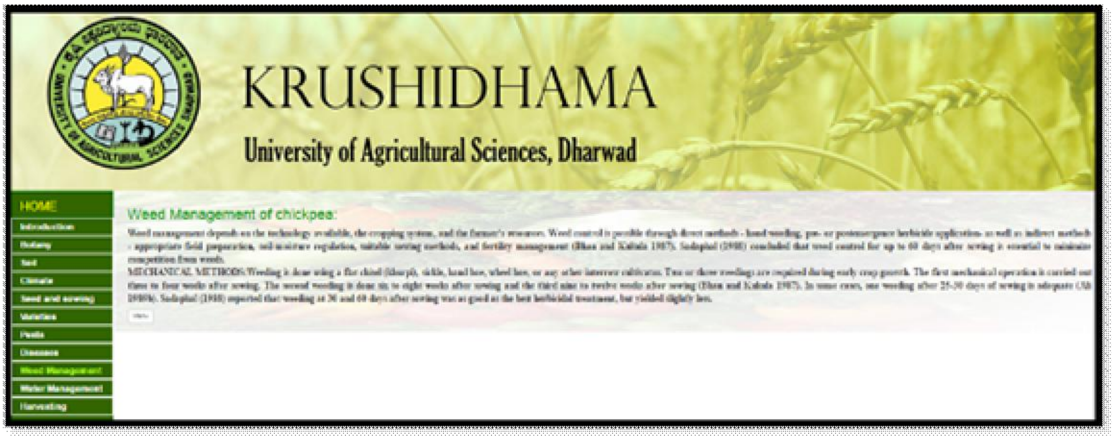


Click on **'Diseases'** we get the page of 'disease of Chickpea'

Which contains some important diseases, identification of disease, symptoms and management practice for the particular disease.

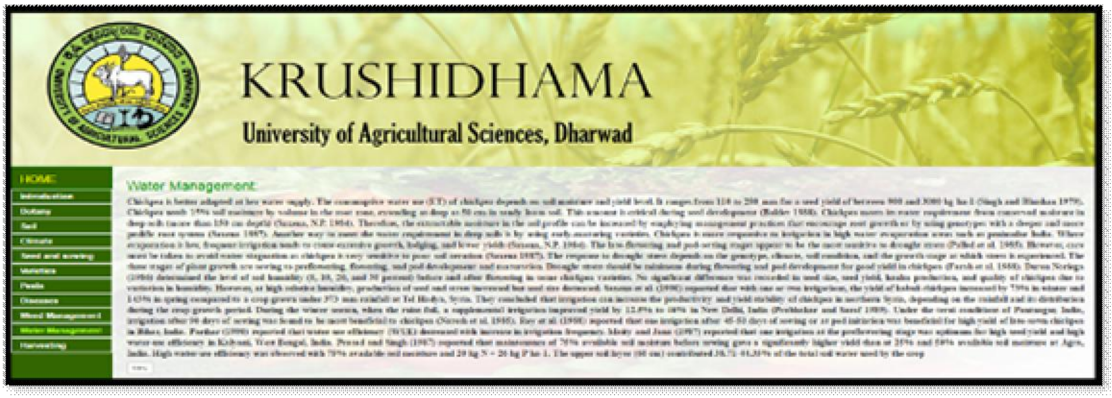
Click on **'Weed management'**

Which will display about how to control the weeds in Chickpea crop.



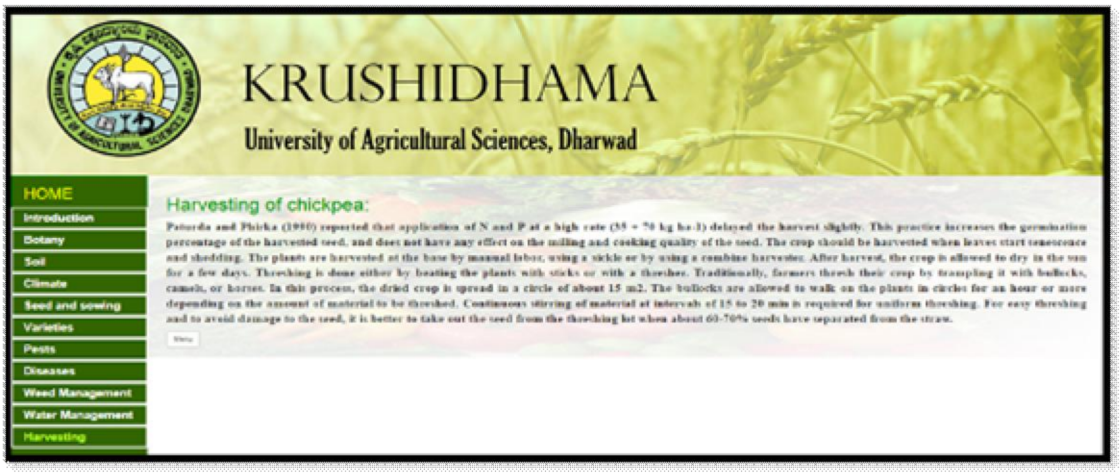
Click on **'water management'**

Which contains the information about water management in Chickpea crop.



Click on **'Harvesting'**

Which helps to know the harvesting period as well as method of harvesting of Chickpea.

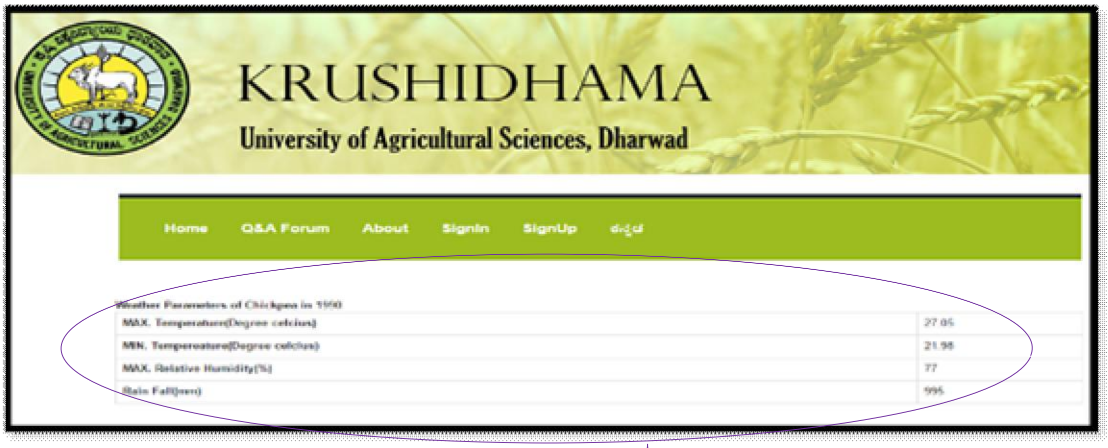


Similarly in case of **'Cowpea'** crop also.

Look at the "**Other information**" which helps to know the area and production of Chickpea and Cowpea crop and weather parameters for a particular period of time in Dharwad district.

Click on **'Weather parameter'** to know about the average of Maximum temperature, Minimum temperature, Relative humidity and Rainfall of particular crop.

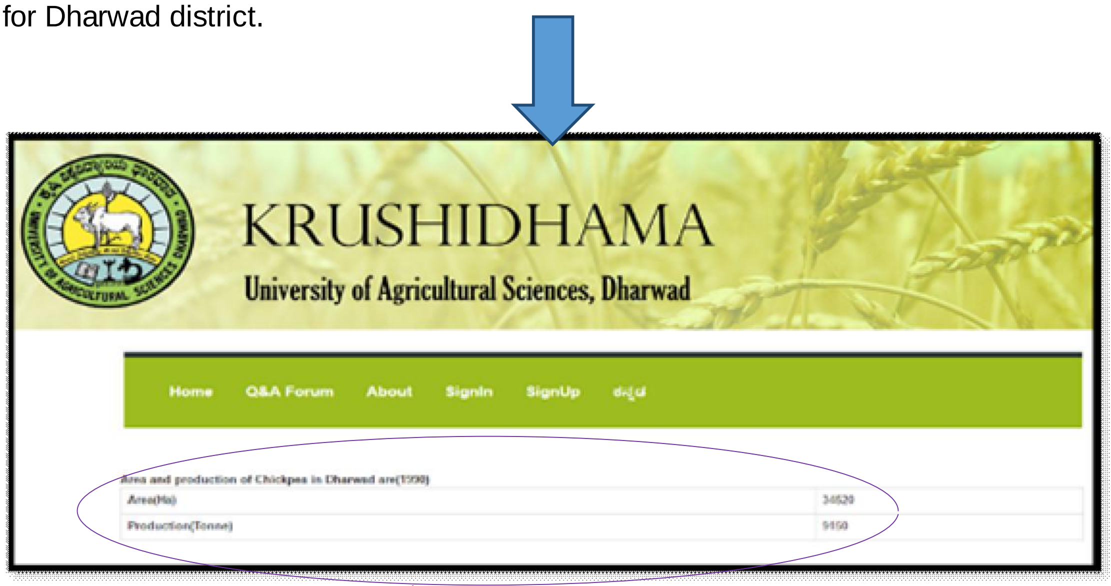
Here select the **crop → year → submit.** Result will appear as shown below:



Which shows the Maximum temperature, Minimum temperature, Relative humidity and Rainfall in Dharwad district.

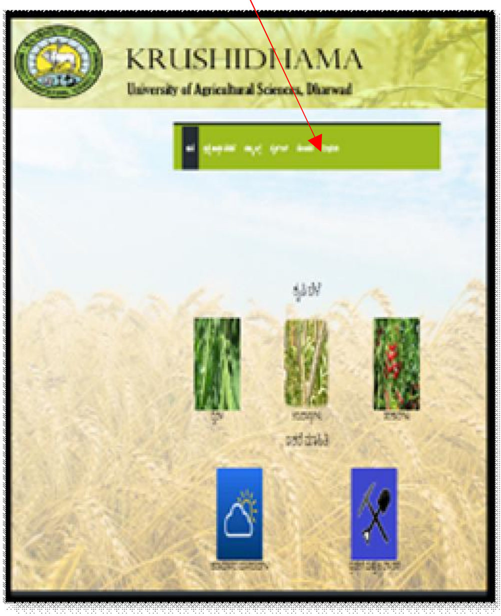
Go back and Click on **Area and production**

After filling mandatory details we will get the area and production of that particular crop for Dharwad district.



Which shows the Area and production of Chickpea crop.

Similarly in **Kannada** version of “**KRUSHIDHAMA**” also



Which contain the information about Botany, Soil, Climate, Seed and sowing, Varieties, Pests, Disease, Weed management, Water management and Harvesting in Kannada language.

DEVELOPMENT OF DECISION SUPPORT SYSTEM ON PULSE CROPS (COWPEA AND CHICKPEA) IN DHARWAD DISTRICT (KARNATAKA)

CHIRANJIB DAS **2016** **DR. ASHALATHA K. V.**
MAJOR ADVISOR

ABSTRACT

The Decision Support System (DSS) has been developed in MySQL (My Structured Query Language) and windows 8 operating system is used. MySQL is relational database management system which provides data definition language to create relations and data manipulation language to execute SQL queries. Secondary data is used for the present research. Software includes seven windows, user has required to feed the mandatory details to get required information of selected crops based on package of practices, area and production. DSS includes question and answer forum through which farmers will be able to query regarding any problems about crops and experts can give their suggestions to the queries. Extensively agricultural extension workers, scientists, researchers can use this software. This DSS is farmers friendly. Farmers, having little aware of computer can use. They can contact with the agricultural organisation, using this type of database system which can help farmers by giving valuable suggestion. Come back facility is there in each window. This DSS can be updated further. Statistical investigation was carried out to know shift in area of pulse crops, instability of selected pulse crops and relationship between area, weather parameters and production of selected crops in Dharwad. Markov chain analysis, Coppock's instability analysis, correlation and multiple regression analysis were used as tools. Markov chain analysis revealed that the retention was highest in chickpea crop and lowest retention was noticed in cowpea and arhar crops, instability analysis revealed that overall instability was higher in case of chickpea than cowpea throughout the periods. Multiple regression results revealed that in case of chickpea crop, maximum temperature relative humidity and rainfall were contributing significantly to the production of chickpea out of five parameters *viz.* area, maximum temperature, minimum temperature, relative humidity and rainfall, maximum temperature has significant negative impact to the production of cowpea crop.