IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 17, Issue 4 Ser. II (Jul. – Aug. 2021), PP 01-08
www.iosrjournals.org

Measuring the Technical Efficiency in Agriculture Farming through CCR Model by Data Envelopment Analysis

Pavan Kumar Donthula[1], Raju Nellutla[2] , V V Haragopal[3]
[1]*Research Scholar, Department of Mathematics, Osmania University, Hyderabad, Telangana, India.*
[2] *Associate Professor, Department of Mathematics & Statistics, Guru Nanak Institutions Technical Campus, Hyderabad, Telangana, India.*
[3] *Professor(Retired), Department of Statistics, Osmania University, Hyderabad, Telangana, India.*

Abstract: *In this paper we analyze the agricultural data by CCR Model through Data Envelopment Analysis (DEA) for the Telangana state. To know the agriculture Technical Efficiency (T.E) of the farmers district wise in Telangana state. The Performance of the districts is presented along with the Peer, Reference Set, Potential Improvements (PI) and Technical efficiency Performance of the state by CCR Model through DEA approach.*
Key Word*: CCR Model, Constant returns to Scale , Data Envelopment Analysis, Peers, Performance, Potential Improvement, Reference set, Technical Efficiency.*

Date of Submission: 14-07-2021 Date of Acceptance: 30-07-2021

I. Introduction

Initiation of agriculture was a revolutionary step in human history. Agriculture farming, which in progress during the Neolithic period of man's survival on earth was initially for subsistence only, but with the increase in population, grew man's need for more agricultural production. Therefore, the necessasity in bringing more land under cultivation in turn necessitated the use of animal power in agriculture. The emerging trends in agricultural are implementations and new technology, varieties of seeds and some new crops were introduced. Farmers was benefitted, to some extent, with the expansion of trade and commerce, improved irrigation facilities, transport and communication system. India adopted significant policy reforms focused on the goal of food grain self-sufficiency. India's Green Revolution began with the decision to adopt superior yielding, disease resistant varieties with better farming knowledge to improve productivity.

Kwimbere [2] applied DEA model to assess the performance of Decision Making Units viz., Engineering, Mathematics and Physics departments of a set of universities in U.K .[3]assessed higher education in Britain and [9] assessed the Performance of Management Schools in Secondary School Examinations of Andhra Pradesh State for academic years 2009-10 and 2010-11 by Data Envelopment Analysis. In this present study we consider the agriculture data for Telangana state to assess which district fares well for the data collected for the year 2018-19 and 2019-20 by CCR by Data Envelopment Analysis, which help the government authorities and formers to plan well for the future years to come for a better efficient cultivation and profits to the farmers.

II. Data Envelopment Analysis

Data Envelopment Analysis (DEA) is relatively "data oriented" and mathematical approach for evaluating the performance of a set of peer entities called decision making entities, which convert multiple inputs in to multiple outputs .In the recent years, the DEA has emerged into a greater variety of application for using evaluating the performance of many different kinds of entities engaged in many different activities in many different contexts in many different countries world over.DEA represents a great progression of continuous advancing for the data analysis , which find extensive use in industry , society , education even in agriculture sector.[12] assessed efficiency of Pomegrante Growers and [4] Performed a critical Data Envelopment Analysis of hospital efficiency in India and found interesting results in health care issues. [15] Assessed Selection and Analysis of Input-Output Variables using Data Envelopment Analysis of Decision Making Units - Indian Private Sector Banks.

III. The CCR Model

3.1 Efficiency Analysis:

The efficiency analysis is always computed to assess the performance of an organization. The Efficiency is an important factor in economic analysis, where the process has a single input and single output, and then the efficiency is defined as:

$$\text{Efficency} = \frac{\text{Output}}{\text{Input}} \qquad (1)$$

The theory of production from the economic point of view then can be considered as a formal model to link inputs and outputs, this theory has several strengths. First , some formal relationship between inputs and outputs exists and a '' best practice '' can be identified by comparing different units transforming in to inputs to output where all units are assessed relative to that of optimum. The production process that occurs in agriculture sectors seems to have the same characteristics of the above economic model. In the agriculture sector- efficient utilization proper harvesting, Technology and human resources as inputs helps in computing the outputs as shown in below.

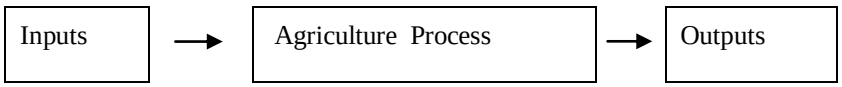

Figure 1: Transformation of Input/ Output Process

3.2 The CCR Model: In Data Envelopment Analysis (DEA) the most widely used model is CCR Model [10] and [11] . A Constant Return to Scale relationship is assumed between Inputs and Outputs. It was the first Data Envelopment Analysis model to be developed CCR after Charnes, Cooper and Rhodes who introduced this. This model is calculates the Overall Efficiency (O.E) for each unit, where both the, Technical Efficiency(T.E) and Scale Efficiency (S.E) are aggregated into one value. The Primal CCR model is explained as follows:

Decision Making Units DMU_j **:** The j[th] Decision Making Unit $j = 1,2,3,\dots,n$.

$\boldsymbol{x_{ij}}$: The amount of the i[th] input of the j[th] Decision Making Units $\boldsymbol{x_{1j}, x_{2j}, xy_{3j}, \dots, x_{nj}}$.

$\boldsymbol{y_{ij}}$: The amount of the j[th] output of the j[th] Decision Making Units $\boldsymbol{y_{1j}, y_{2j}, y_{3j}, \dots, y_{sj}}$

$\boldsymbol{v_i}$: The weight assigned to the i[th] input , $i = 1,2,3,\dots,n$.

$\boldsymbol{u_r}$: The weight assigned to the r[th] output , $r = 1,2,3,\dots,s$.

The Fractional Programming Problem (FPP) is :

$$\textbf{Max } \boldsymbol{R = \frac{u_1y_{1k} + u_2y_{2k} + u_3y_{3k} \dots + u_sy_{sk}}{v_1x_{1k} + v_2x_{2k} + v_3x_{3k} \dots + v_mx_{mk}}}, \qquad \boldsymbol{k = 1, 2, 3, \dots, n} \qquad (2)$$

$$\textbf{Subject to constraints}: \boldsymbol{\frac{u_1y_{1j} + u_2y_{2j} + \cdots + u_sy_{sj}}{v_1x_{1j} + v_2x_{2j} + \cdots + v_mx_{mj}} \leq 1}, \qquad \mathbf{j = 1, 2, 3, \dots, n}. \qquad (3)$$

$$\textbf{Non negativity} \quad \boldsymbol{u_1, u_2, u_3, \dots, u_s \geq 0} \ \& \ \boldsymbol{v_1, v_2, v_3, \dots v_m \geq 0} \qquad (4)$$

The ratio of input and output should not exceed 1 for every decision making unit. The objective is to maximize the decision making units. The optimal value of R^* is at most one. Mathematically, non negativity constraints (4) is not sufficient for the fractional terms in (3) to have a positive value . Assuming that all outputs have some non zero and this leads to be the reflected in the weights $\boldsymbol{u_r}$ and $\boldsymbol{v_i}$ being assigned positive values. Now we replace the Factional Program (FP) by the following Linear Programming Problem (LPP),

$$\textbf{Max } \boldsymbol{R(u, v) = u_1y_{1k} + u_2y_{2k} + u_3y_{3k} + - - - + u_sy_{sk}} \qquad (5)$$

$$\textbf{Subject to } \boldsymbol{v_1x_{1j} + v_2x_{2j} + v_3x_{3j} + - - - + v_mx_{mj} = 1} \qquad (6)$$

$$\boldsymbol{u_1y_{1j} + u_2y_{2j} + u_3y_{3k} + - - - + u_sy_{sj} \leq v_1x_{1j} + v_2x_{2j} + v_3x_{3j} + - - - + v_mx_{mj}} \qquad (7)$$

$$\boldsymbol{u_1, u_2, u_3, \dots, u_s \geq 0, v_1, v_2, v_3, \dots v_m \geq 0} \qquad (8)$$

Optimal Solution $(\boldsymbol{v^*, u^*, R^*})$

The ratio scale is evaluated by using the Primal Problem. The primal becomes

$$\boldsymbol{Max \ R^*(v^*, u^*) = \frac{\sum_{r=1}^{s} u_r^* y_{rk}}{\sum_{i=1}^{m} v_i^* x_{ij}}} \qquad (9)$$

$$\boldsymbol{R^*(v^*, u^*) = \sum_{r=1}^{s} u_r^* y_{rj}} \qquad from \ (2) \qquad (10)$$

$$\textbf{Subject to constraints}: \boldsymbol{\sum_{r=1}^{s} u_r^* y_{rj} - \sum_{i=1}^{m} v_i^* x_{ij} \leq 0} \qquad \boldsymbol{j = 1, 2, 3, \dots, n} \qquad (11)$$

$$\sum_{i=1}^{m} v_i x_{ik} = 1 \qquad (12)$$

Non negativity $u_r \geq 0, v_i \geq 0$

The above linear programming problem yield the Optimal Solution R^*, where efficiency score is called Technical Efficiency or CCR Efficiency for the particular DMU_j and Efficiency scores for all of them are obtained by repeating them for each DMU_j , $j = 1,2,3,\dots,n$ .The value of R^* is always less than or equal to 1 . DMUs for which $R^* < 1$ are relatively inefficient and those for which $R^* = 1$ are relatively efficient, having their virtual input-output combination points on the frontier. The frontier itself consists of linear facts spanned by efficient units of the data, and the resulting frontier production function has no unknown parameters.

3.3 The Reference Set (R.S): When we observe the DMU has CCR inefficient $R^* < 1$ then there must be one constraint produce equality between the left hand side and right hand side of the equation(7) other wise , R^* could be enlarged. Let $j \in \{1,2,3,\dots,n\}$ be

$$E_k' = \left\{ j: \sum_{r=1}^{s} u_r^* y_{rj} = \sum_{i=1}^{m} v_i^* x_{ij} \qquad j = 1,2,3,\dots,n \right\} \qquad (13)$$

The subset of E_k and $E_k^{'}$, composed of CCR efficient DMUs , is called the Reference Set(RS) or the peer group to the DMU1, DMU2, DMU3,…, DMUk.

3.4 Potential Improvement (PI): An efficient study not only provides an efficiency score per each unit but also indicates by how much and in which areas an inefficient unit needs to improve in order to improve the efficiency. This information can enable the targets to be set which could help inefficient units to be improved in their performance.

3.5 Reference Comparison(RC): If the assessment of units was found to be inefficient then it is felt to be justified that the information provided can be used as a basis for setting targets for the units .As a first step in setting targets, the inefficient unit should be compared with the units in its reference set.

3.6 Peer Group (PG): Data Envelopment Analysis identifies for each inefficient unit a set of excellent units, called Peer Group, which includes those units that are efficient if evaluated with the optimal weights of inefficient unit. The Peer Group, made up of Decision Making Units which are characterized by operating methods similar to the inefficient unit being examined, which is a realistic term of comparison which unit aim to imitate in order to improve its performance. Another name for the peer group is reference set.

3.7 Constant Returns to Scale (CRS):

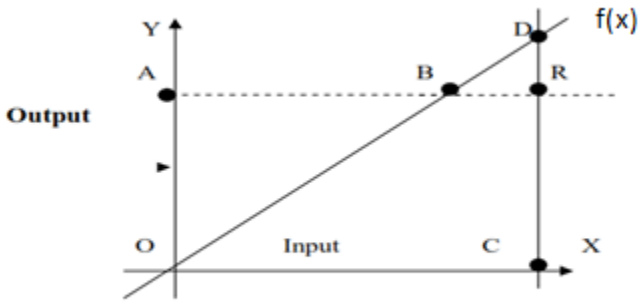

Fig 2 Constant Returns to Scale

From the above figure we understand that, a production of a single output is illustrated graphically. In fig (2) it can be seen that the function *f(x),* where *f(x)* is a straight line and has a single slope. Hence, for every unit increase in the input that goes into the process, the output produced increases by a constant proportional quantity; hence it represents Constant Returns to Scale (CRS). In this case, R could be projected onto the frontier either under an input- reducing consideration or an output – increasing consideration. B and D are projected points on the frontier obtained for comparison.

IV. Data Consideration And Analysis

The results of Data Envelopment Analysis (DEA) for district wise CCR Model Technical Efficiency (T.E) for the year 2018-19 is presented below:

Table 1 : District wise Technical Efficiency(TE) for the year 2018-19

S. No	District(DMU)	CCR Technical Efficiency R^*	No. of References	No. of Peers	Name of the Peers
1	ADILABAD	0.837	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
2	BHADRADRI	0.698	0	2	KHAMMAM,VIKARABAD
3	JAGTIAL	1	8	0	JAGTIAL
4	JANGAON	0.882	0	2	JAGTIAL,KHAMMAM
5	JAYASHANKAR	0.965	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
6	JOGULAMBA	0.734	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
7	KAMAREDDY	0.766	0	3	JAGTIAL,KARIMNAGAR, KHAMMAM
8	KARIMNAGAR	1	2	0	KARIMNAGAR
9	KHAMMAM	1	22	0	KHAMMAM
10	KOMARAM BHEEM	0.966	0	2	VIKARABAD, WARANGAL RURAL
11	MAHABUBABAD	0.882	0	3	KHAMMAM,VIKARABAD, WARANGAL RURAL
12	MAHABUBNAGAR	0.957	0	2	VIKARABAD, WARANGAL RURAL
13	MANCHERIAL	0.848	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
14	MEDAK	0.853	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
15	MEDCHALMALKAJGIRI	0.470	0	2	JAGTIAL,KHAMMAM
16	MULUGU	0.926	0	3	KHAMMAM,NIZAMABAD,WARANGAL RURAL
17	NAGARKURNOOL	0.833	0	2	VIKARABAD, WARANGAL RURAL
18	NALGONDA	0.586	0	2	JAGTIAL,KHAMMAM
19	NARAYANPET	0.915	0	2	VIKARABAD,WARANGAL RURAL
20	NIRMAL	0.953	0	3	KHAMMAM,NIZAMABAD, WARANGAL RURAL
21	NIZAMABAD	1	6	0	NIZAMABAD
22	PEDDAPALLI	0.94	0	3	JAGTIAL,KHAMMAM, NIZAMABAD
23	RAJANNA	0.899	0	3	KHAMMAM,NIZAMABAD,WARANGAL RURAL
24	RANGAREDDY	0.816	0	2	KHAMMAM,VIKARABAD
25	SANGAREDDY	0.97	0	3	KHAMMAM,VIKARABAD,WARANGAL RURAL
26	SIDDIPET	0.733	0	2	KHAMMAM,VIKARABAD
27	SURYAPET	0.698	0	2	JAGTIAL,KHAMMAM
28	VIKARABAD	1	15	0	VIKARABAD
29	WANAPARTHY	0.911	0	3	KHAMMAM,NIZAMABAD, WARANGAL RURAL
30	WARANGAL RURAL	1	16	0	WARANGAL RURAL
31	WARANGAL URBAN	1	1	0	WARANGAL URBAN
32	YADADRI	0.525	0	2	JAGTIAL,KHAMMAM

From the above Table 1 the Technical Efficiency (T.E) variation for the 32 districts has the following bound $0.470 \leq R^* \leq 1.000$. Also seven districts have been emerged as efficient namely Jagtial, Karimnagar, Khammam, Nizamabad, Vikarabad, Warangal rural, Warangal urban and the remaining 25 districts input loses due to CCR Technical efficiency. Potential improvement is required in order to improve in their Performance with regards to yield of crops in this state.

From the Table 1 it is clear that Jagtial, Karimnagar, Khammam, Nizamabad, Vikarabad, Warangal rural , Warangal urban are Technically (CCR) Efficient as compared to the 32 districts. It is observed that the Peers with all other districts seem to be Jagtial, Karimnagar, Khammam, Nizamabad, Vikarabad, Warangal rural ,

Warangal urban and Khammam district is having highest references. Peer contribution of this district is more comparable to other districts.

In DEA every efficient DMU by its self role model. For Example, Jagtial, Karimnagar, Khammam, Nizamabad, Vikarabad, Warangal rural , Warangal urban are Technically (CCR) Efficient by its self is a role model. From the above table it is noticed that the Technical Efficiency (T.E) of Nalgonda district is 0.586 Hence, Nalgonda district is technically inefficient. If returns to scale is constant it could have produced its current outputs 0.586 or 58.60 percent of inputs. Thus , removal of all inefficiencies is achieved by reducing all inputs by 0.414 or Approximately,41% of their observed values .In fact , based on the reference set and Peer Weight, we can express the input and output values needed to bring Nalgonda district in to efficient status. Similarly we analyse the remaining inefficient district in order to improving their performance towards improve the yield of crops in both Rabi and Kharif seasons.

The Distribution of Scores Graph for the year 2018-2019 is presented below:

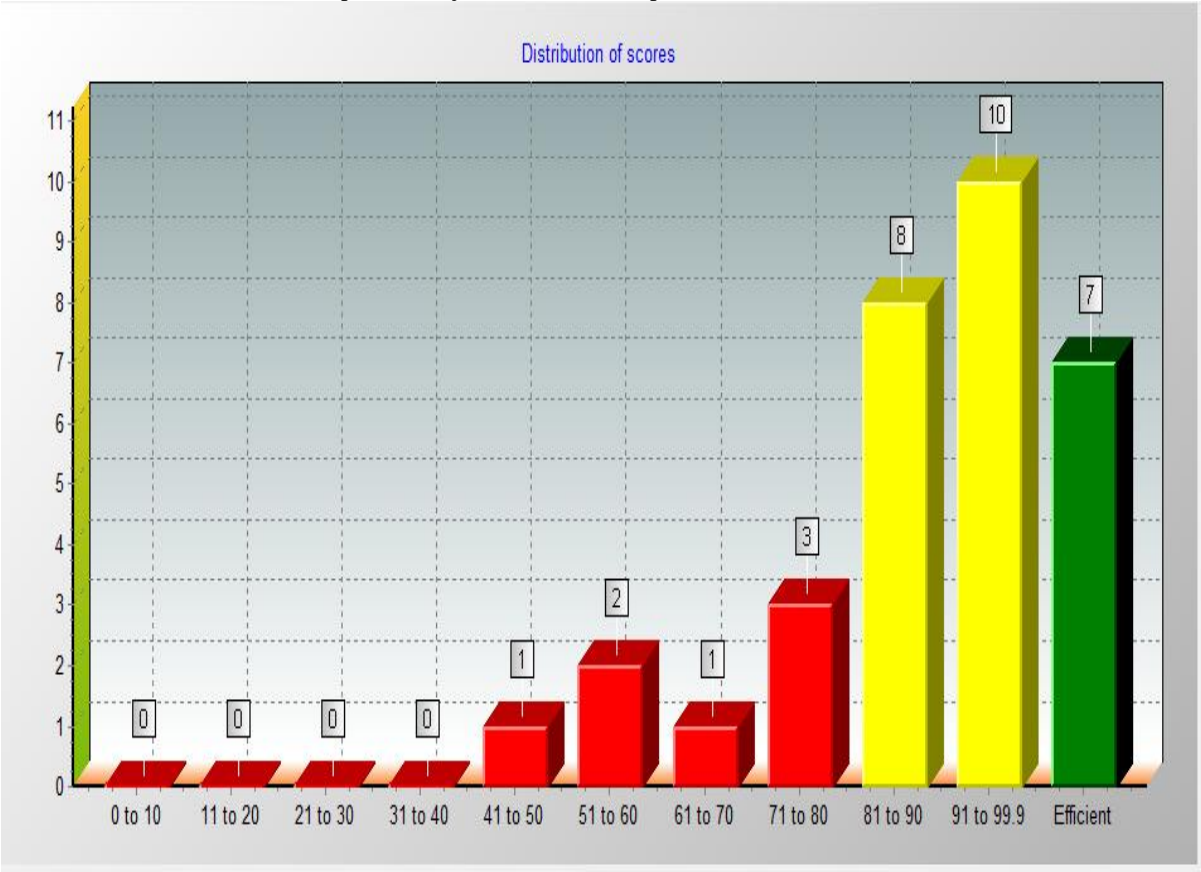

Figure 3: The Distribution of Scores Graph for the year 2018-19

From the above distribution of score graph , we observe that the score limit 41-50 is 1 DMU, 51-60 is 2 DMUs, 61-70 is 1 DMU, 71-80 is 3 DMUs (districts) , 81-90 score is 8 DMUS(districts), 91-99.9 score limit 10 DMUs (districts) are Technically inefficient frontier and 7 DMUs are in efficient status.

Table 2: District wise Technical Efficiency for the year 2019-20

S. No	District(DMU)	CCR Technical Efficiency *R**	No. of References	No. of Peers	Name of the Peers
1	ADILABAD	0.986	0	3	MEDAK,VIKARABAD, WARANGAL RURAL
2	BHADRADRI	1.000	2	0	BHADRADRI
3	JAGTIAL	0.887	0	3	MEDAK,SURYAPET, WARANGAL RURAL
4	JANGAON	0.962	0	2	KHAMMAM,MULUGU
5	JAYASHANKAR	0.942	0	2	KHAMMAM,MULUGU
6	JOGULAMBA	0.879	0	3	MAHABUBNAGAR,MEDAK, WARANGAL RURAL

7	KAMAREDDY	0.946	0	3	MEDAK,SURYAPET, WARANGAL RURAL
8	KARIMNAGAR	0.868	0	3	KHAMMAM,NIRMAL, WARANGAL RURAL
9	KHAMMAM	1.000	10	0	KHAMMAM
10	KOMARAM BHEEM	0.778	0	1	VIKARABAD
11	MAHABUBABAD	0.882	0	3	KHAMMAM,MAHABUBNAGAR, WARANGAL RURAL
12	MAHABUBNAGAR	1.000	8	0	MAHABUBNAGAR
13	MANCHERIAL	0.912	0	2	MULUGU,VIKARABAD,
14	MEDAK	1.000	9	0	MEDAK
15	MEDCHALMALKAJGIRI	0.910	0	2	VIKARABAD,WARANGAL RURAL
16	MULUGU	1.000	4	0	MULUGU
17	NAGARKURNOOL	0.970	0	3	KHAMMAM,MAHABUBNAGAR , WARANGAL RURAL
18	NALGONDA	0.888	0	3	KHAMMAM,VIKARABAD, WARANGAL RURAL
19	NARAYANPET	0.964	0	2	BHADRADRI, MAHABUBNAGAR
20	NIRMAL	1.000	5	0	NIRMAL
21	NIZAMABAD	0.928	0	3	MEDAK,SURYAPET, WARANGAL RURAL
22	PEDDAPALLI	0.868	0	2	KHAMMAM, NIRMAL
23	RAJANNA	0.959	0	3	MEDAK,SURYAPET, WARANGAL RURAL
24	RANGAREDDY	0.928	0	2	MAHABUBNAGAR, VIKARABAD
25	SANGAREDDY	0.855	0	2	MAHABUBNAGAR, VIKARABAD
26	SIDDIPET	0.966	0	3	MEDAK,SURYAPET,WARANGAL RURAL
27	SURYAPET	1.000	6	0	SURYAPET
28	VIKARABAD	1.000	8	0	VIKARABAD
29	WANAPARTHY	0.889	0	3	MAHABUBNAGAR,MEDAK, WARANGAL RURAL
30	WARANGAL RURAL	1.000	15	0	WARANGAL RURAL
31	WARANGAL URBAN	0.996	0	2	KHAMMAM, NIRMAL
32	YADADRI	0.930	0	3	KHAMMAM,NIRMAL, WARANGAL RURAL

From the above Table 2 the Technical Efficiency variation for the 32 districts has the following bound $0.778 \leq R^{*} \leq 1.000$. Also nine districts have been emerged as efficient and the remaining 23 districts input lose due to CCR Technical efficiency. Potential improvement is required in order to improve in their performance with regards to yield of crops in both Rabi and Kharif seasons.

From the Table 2 it is clear that Bhadradri, Khammam , Mahabubnagar,Medak, Mulugu , Nirmal, Suryapet, Vikarabad , Warangal Rural are Technically (CCR) Efficient when compared to the 32 districts. It is observed that the Peers to the all other districts seem to be Bhadradri, Khammam , Mahabubnagar,Medak, Mulugu , Nirmal, Suryapet, Vikarabad , Warangal Rural. Warangal Rural district is having highest references. Peer contribution of this district is more comparable to other districts.

In Data Envelopment Analysis (DEA) every efficient DMU by its self role model. For Example, Bhadradri, Khammam , Mahabubnagar,Medak, Mulugu , Nirmal, Suryapet, Vikarabad , Warangal Rural are Technically (CCR) Efficient by its self is a role model districts. From the above table 2 is noticed that the Technical Efficiency (T.E) of Komaram Bheem district is 0.778. Hence, Komaram Bheem district is technically inefficient. If returns to scale is constant it could have produced its current outputs 0.772 or 77.20 percent of inputs. Thus , removal of all inefficiencies is achieved by reducing all inputs by 0.228 or Approximately,23% of their observed values .In fact , based on the reference set and Peer Weight, we can express the input and output values needed to bring Komaram Bheem district in to efficient status. Similarly we analyse the remaining inefficient district in order to improve their performance towards improving the yield of crops.

The distribution of score graph for the academic year 2019-20 is presented below:

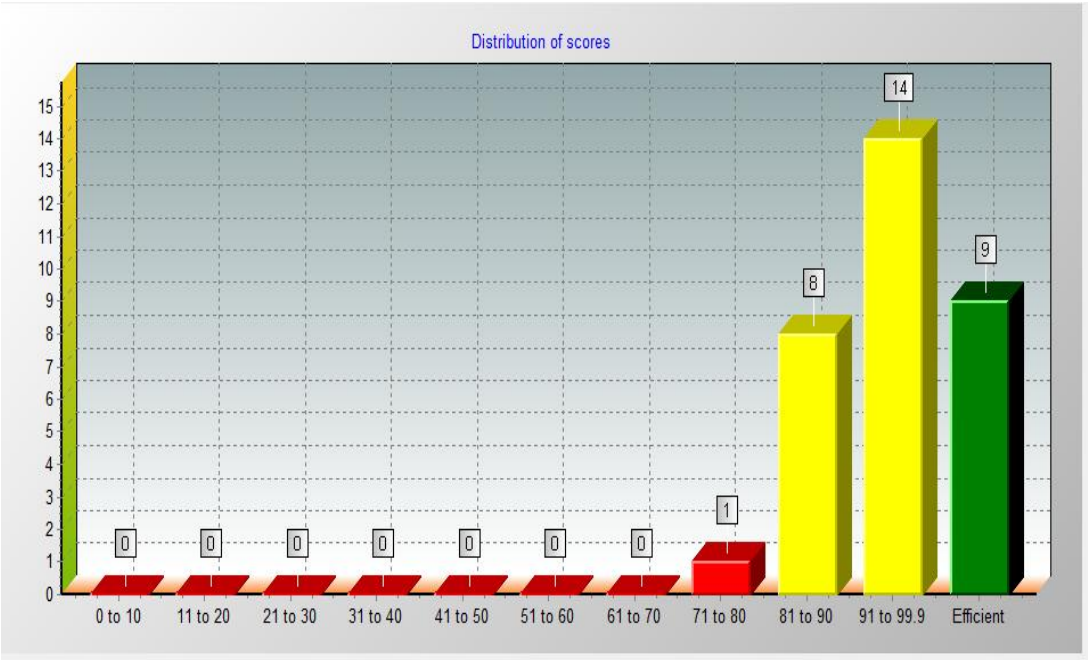

Figure 4: The Distribution of scores graph for the year 2019-20

From the above distribution of score graph , we observe that the score limit 71-80 is 1 DMU (district) , 81-90 score is 8 DMUS(districts), 91-99.9 score limit 14 DMUs (districts) are Technically inefficient frontier and 9 DMUs are in efficient status.

The Summary of CCR Model Technical Efficiency (T.E) for the years 2018-19 and 2019-20 is presented below for the clarity of data analysis.

Table 3: Summary of CCR Technical Efficiency (T.E)

	2018-19	2019-20
Average of T.E	0.8613	0.940
S.D of T.E	0.1442	0.0573
C.V of T.E	16.74%	6.10%
Minimum Technical Efficiency	0.470	0.778
Maximum Technical Efficiency	1	1
No. of Efficient DMUS (districts)	8	9
Total number of DMUs (districts)	32	32

In 2018-19 the average agriculture Technical Efficiency in 32 districts is 0. 8613, the standard deviation is 0.1442 and C. V is 16.74%. The highest and lowest technical efficiency is 1 and 0.470 respectively. In 2019-20 the average agriculture Technical efficiency in 32 districts is 0.940, the standard deviation is 0.0573 and 6.10%. The highest and lowest technical efficiency is 1 and 0.778 respectively.

V. Conclusions

From this data analysis we found that for the year 2018-19 Jagtial, Karimnagar, Khammam, Nizamabad, Vikarabad, Warangal rural, Warangal urban district farmers performs well as per CCR Technical Efficiency. For the year 2019-20 Bhadradri, Khammam , Mahabubnagar, Medak, Mulugu , Nirmal, Suryapet, Vikarabad , Warangal Rural farmers performs well as per CCR Technical Efficiency. Remaining districts Potential Improvement (P.I) is required for improving in their performance with regards to yield of crops. Khammam, Vikarabad, Warangal rural district farmers performs well for the both years. If returns to scale is constant in CCR model it could have produced its current outputs percent of inputs. Thus , removal of all inefficiencies is

achieved by reducing all inputs by % of their observed values .In fact , based on the reference set and peer weight, we can express the input and output values needed to bring every DMUs (districts) in to efficient status. The Nation is motivated to find ways and means to continue its increase rapidly population effectively fed. On one hand it is facing the problem of declining productivity and on the other, challenges posed by liberalization. In such a scenario, leveraging the available natural resources and existing infrastructure is the only way to generate the ends to meet.

References

[1]. Rutter , M. & Maughan B., *'' School effectiveness findings 1970-2002 '',* Journal of School Psychology ,vol.40, No.6, pp.451-475,2002.

[2]. Kwimbere, F.J. , *'' Measuring efficiency in not-for-profit organizations: an attempt to evaluate efficiency in selected UK university departments''*. M.Sc. thesis, School of Management, University of Bath,1987.

[3]. Johnes, J, *''Performance assessment in higher Education in Britain'',* European Journal of Operational Research, vol. 2, pp. 18–33,1996.

[4]. M. Goverdhan, Raju Nellutla, V. V Haragopal, *''A Critical Data Envelopment Analysis of Hospital efficiency in India ''* , International Journal of Scientific Research, Vol-5,issue2,pp.471-475, 2016.

[5]. Raju Nellutla, V. V Haragopal , *'' Technical efficiency Management wise Schools in Secondary School Examinations of Andhra Pradesh State by CCR Model''* , IOSR Journal of Mathematics, Vol-13,issue1,pp.1-8,2017.

[6]. Raju Nellutla, V. V Haragopal, *'' Performance of Management Schools in Secondary School Examinations of Andhra Pradesh State by Data Envelopment Analysis'',* International Journal of Scientific Research, Vol-4,issue9,pp.179-182,2015.

[7]. Pina ,V., Y Torres , L.,'' Analyse through DEA Teaching activity of the Account Department'', in Spanish Public University,1995.

[8]. Raju Nellutla, M. Goverdhan, V.V. Haragopal, "Measuring the Technical Efficiency of Decision Making Units by CCR Model in Data Envelopment Analysis," *International Journal of Scientific Research in Mathematical and Statistical Sciences*, Vol.5, Issue.4, pp.54-60, 2018.

[9]. Raju Nellutla, V. V. Haragopal, *''Data Envelopment Analysis of SSC Public Examinations 2009 -2011 of Andhra Pradesh''* , Global Journal for Research Analysis, vol -4,issue 7,pp.141-144,2015.

[10]. Charnes, A , W. Cooper, &E., Rhodes , *''Measuring the Efficiency of decision making units'',* European Journal of Operational Research vol. 2, pp. 429–444,1978.

[11]. Banker, R.D., R.F. Charnes, & W.W. Cooper *,''Some Models for Estimating Technical and Scale Inefficiencies in Data Envelopment Analysis'',* Management Science vol. 30, pp. 1078–1092, 1984.

[12]. G.D. Rede and K. Bhattacharyya *'' Efficiency of Pomegranate Growers: A Data Envelopment Analysis'',* Economic Affairs, Vol. 65, No. 2, pp. 161-166, June 2020.

[13]. Elena Toma, Carina Dobre et. all *'' DEA applicability in assessment of agriculture efficiency on areas with similar geographically patterns'',* Agriculture and Agricultural Science Procedia Vol 6 ,pp. 704 – 711,2015.

[14]. Sun Ye **,** **''**Appraisal of Agriculture Production Efficiency in Shandong Province Based on Data Envelopment Analysis''**,** International Journal of Managerial Studies and Research (IJMSR) Volume 3, Issue 1, PP 12-17, January 2015.

[15]. B. Vittal, Raju Nellutla, M. Krishna Reddy **,''** Selection and Analysis of Input-Output Variables using Data Envelopment Analysis of Decision Making Units - Indian Private Sector Banks **''**, International Journal of Engineering and Advanced Technology (IJEAT) Volume-10 Issue-5, pp 119-126,June2021.

Pavan Kumar Donthula, et. al. "Measuring the Technical Efficiency in Agriculture Farming through CCR Model by Data Envelopment Analysis." *IOSR Journal of Mathematics (IOSR-JM)*, 17(4), (2021): pp. 01-08.