*Journal of Water Sciences Research,*
*ISSN: 2251-7405 eISSN: 2251-7413*
*Vol.6, No.1, Winter 2014, 17-29, JWSR*

# *Evaluation of Water Use Productivity Indicators in the Main Agricultural Products of Iran*

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Received: 29 April 2013 Accepted: 19 October 2013

***ABSTRACT***

Although the agricultural sector consumes more than 90% of the extracted water, its efficiency is lower than other sectors. Also, according to the population growth and critical role of food security, and the necessity to supply water to other sectors, an increasing pressure to save water, optimized consumption and increasing water use productivity in agriculture will occur in the future. Nowadays improving water use productivity and producing more crops per water unit consumed are the main objectives of agricultural activities. There are several indexes to evaluate the water use productivity in agriculture. Hence, investigation on the capabilities and deficiencies of each index is necessary. In this study, four indexes of water use productivity including produced crop per one cubic meter of water (CPD), gross benefit per one cubic meter of water (BPD), net benefit per one cubic meter of water (NBPD) and benefit to cost ratio for three major crops in Iran, namely wheat, barley and potato are evaluated and located with geographic information system (GIS). Results show that by combining all four indexes, wheat in northern and western areas and Khuzestan province, barley in Khorasan Razavi province and northern and central areas and potato in Hamedan province and northeast areas have a better distribution in Iran.

***KEYWORDS***

Water use, Productivity indexes, Geographic information system, Gross benefit, Values added

## 1. Introduction

In Middle East countries, especially in Iran it is necessary to determine the real rate of the water use productivity for different agricultural products and to use software and hardware methods in order to promote and optimize its qualitative amount due to special climate conditions, limitations of water resources and increase of agricultural products. In this regard, attention to the optimal use of natural facilities and resources (e.g., land, water and other agricultural products), increase in productivity of production resources, improvement of welfare level and income of producers as well as selection of the effective and efficient pattern of the productivity system of lands seem to be of significant importance.

Considering the warm and dry climate of Iran, the main restricting factor of the agricultural development and production increase is the shortage of water. Agriculture sector will surely face more shortage and restrictions in the future considering the increasing demand for water by urban and industrial sectors (Jafari and Soltani, 2000). Current amount of agricultural products of irrigated farms in Iran is more than 57 million tons, whereas

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according to the economic, social and cultural developments, the amount of agricultural products of irrigated farms should become at least more than 186 million tons in 2021. In order to achieve this production level in 2021, and taking the current water use productivity of 0.7 ($kg/m^3$) into consideration, regardless of the combination of agricultural products and the different levels of precipitation at different areas, the amount of the required water will be more than 266 billion cubic meters which cannot be gained considering the total amount of precipitation as well as the water that could be obtained from subterranean and surface resources. Hence there is no option other than increasing the productivity of water consumption in the irrigated farmlands (Faryab) of the country up to 1.8 to 2 ($kg/m^3$) (Ashgar Tousi and Tashakori Beheshti, 2005). Khazaei (2000) also stated that it is necessary to meet the major part of the requirements of agricultural development through economizing the consumption and increasing water use productivity. Considering the limited production resources and factors, efforts should be taken to use the existing resources and products efficiently and optimally in order to be able to increase the production using the current usage level of agricultural products. In order to increase the productivity of production factors, the factor (s) reducing production has to be identified and directed toward the promotion of production, planning and further research over the identified factor (s).

Different researches regarding water use productivity for different agricultural products were conducted at regional scale. A Study at Sirsai region in India by Singh (2003) showed the mixture of Agro-hydrological model of soil–water–atmosphere of the plant at farm scale together with field information, remote assessment and geographical information system, and increased the credibility of possible simulation of water productivity from farm scale to the regional scale.

Kijne et al. (2003) stated that the original meaning of water productivity is to understand how the different existing agricultural production systems in a field or region (considering the water shortage) could use water more effectively.

Molden et al. (2003) also explained that the meaning of water productivity is used differently. They attributed the productivity to the proportion of output unit (s) over input unit (s).

Another study by Oweis and Hachum (2003) concentrated on research regarding the improvement of water productivity in dry farming areas of west Asia and North Africa. Also Ahmad et al. (2004) conducted analyses to identify time and place variants in productivity of water systems to cultivate rice–wheat in Pinjab, Pakistan at farm scale. The results showed that differences in water consumption, cultivation date, and use of fertilizers, soil quality and socio–economic conditions could make changes to the place, and that the quantity and time of precipitation is also an important factor in time changes.

Neirizi and Fakhrdavoud (2008) determined the wheat water use productivity in Chenaran as 0.38, 0.76 and 0.44 Kg per unit of consumed water, respectively and the sugar beet water use productivity as 1.8, 3.5 and 1.9 ($kg/m^3$), respectively. The increased water use productivity in Torbat-e-Heidarieh farm was due to the fact that the farm benefited from sprinkler irrigation system and a more scientific management.

Montazar and Kosari (2007) studied the results from 73 researches in 13 different provinces over 11 crops to investigate the effect of changes in quantitative rates of water use productivity indexes. They reported that a comparison between the water use productivity of the studied crops in Iran and international rates showed that the range of changes of productivity index of agricultural products in Iran is very vast. In order to find better methods to use water, water use productivity indexes could be used. These methods and indexes help to assess the method of using water and land as well as the impact of each agricultural product on the system performance. Using these indexes, the performance of one network or irrigation system could be compared with the performance of other internal and/or external networks.

The objective of this research is to study and compare different water use productivity indexes for different crops including wheat, barley and potato in Iran, the geographical distribution of water use productivity throughout the country as well as access to the best indexes in assessments and the most productive products.

## 2. Materials and Methods

As it was pointed out, the water use productivity in farming means the agricultural product per water product. Considering the variety of the crops of agricultural sector that could be relevant to the product quality, net value of the produced crop, gross benefit, added value of the produced crop, employment, self-sufficiency, etc. indexes were presented to study the productivity. Among the most common productivity indexes of water in agriculture, four indexes namely crop production per cubic meter of water (Crop per Drop – CPD), gross benefit per cubic meter of water (Benefit per Drop – BPD), net benefit per cubic meter of water (Net Benefit per Drop – NBPD) and benefit per cost (B/C) could be noted.

In Crop per Drop (CPD) index, the amount of water productivity is assessed by the amount of produced crop per unit of consumed water. Although calculation of this index is easy, since the amount of crops of different plants is different, the index cannot be used to compare the water use productivity of various plants.

In Benefit per Drop (BPD) index, the amount of water use productivity per gross benefit from selling the produced crop per unit of consumed water is calculated. Since in this index the gross benefit obtained from selling the product is taken into account, the precision is more than Crop per Drop (CPD) and it could be used to compare the water productivity of different plants. On the other hand, since in this method the amount of spent costs is not taken into account, proper precision is missing to compare the plants that do not have similar production costs.

The other index to measure the water productivity in agriculture is Net Benefit per Drop (NBPD) index which is calculated by the net benefit from selling the product per unit of the consumed water. To calculate this productivity index, the net benefit product and/or value added products are taken into consideration. Although it is slightly difficult to calculate this index, it has a higher precision in comparison with other indexes.

Hence the water use productivity indexes studied in this research are as follows (Ehsani and Khaledi, 2003):

Production of the Crop per one cubic meter of consumed water = Crop per Drop (CPD)

$$CPD = {}^{Produced\ Crop}/_{Consumed\ Water} \tag{1}$$

Gross benefit per one cubic meter of consumed water = Benefit per Drop (BPD)

$$BPD = {}^{Sold\ Product}/_{Consumed\ Water} \tag{2}$$

Net benefit per one cubic meter of consumed water = Net Benefit per Drop (NBPD)

$$NBPD = {}^{Net\ Benefit}/_{Consumed\ Water} \tag{3}$$

Benefit per Cost (B/C)

$$^{B}/_{C} = {}^{Benefit}/_{Cost} \tag{4}$$

The sustained costs to supply water for farming are different in various irrigation plans, thus benefit to cost ratio could be used as a water use productivity index.

Scattered studies were conducted at national level and regional level to enhance water use productivity of different crops. There is a major need at national level to conduct comprehensive research over important and fundamental crops that are mostly required by the people.

In Iran three major crops, i.e. wheat, barley and potato are in the groups of most important and fundamental crops that play a significant role in the daily lives of the Iranian people. That is why this study concentrates on reviewing the water use productivity indexes of these three crops using geographical information system and ArcGIS10 software in order to assess the pattern of farming these crops from water consumption point of view by calculating the productivity of the crops.

In order to calculate the consumed water for each of the above indexes, the net irrigation requirement was initially calculated according to the data of 165 synoptic meteorological centers throughout Iran using CROPWAT software and Water National Document (NETWAT software). It is worth mentioning that the average effective precipitation was also taken into consideration in order to calculate the quantities of the net requirement. In order to calculate the productivity index, the real consumed water or in other words, the gross irrigation requirement of plants as one crop was the basis of calculation. For this purpose, the gross irrigation requirement is calculated considering the irrigation efficiency of each province and the results are shown in Table 1.

Then the performance, the gross value of production, the total costs of production, the gross benefit and added value of the crops are required to calculate each of the four water use productivity indexes for the crops. The gross value of production is the result of adding up the value of the major crops and the minor crops. The gross benefit is the result of the difference between the gross value of crops and the total production costs, and the added value is the result of adding up the gross benefit and the laborer's costs. The laborers' cost is estimated as the result of multiplying person–day–work by laborers' value that was 129,900 Rials in 1391(20 March 2012 - 20 March 2013). The costs to supply irrigation water were also taken into account in the studied production costs.

Table 1. Efficiency of irrigation water in Iran (Sohrab & Abbasi, 2009) and gross irrigation requirements of Wheat, Barley and Potato

| Province | Efficiency (%) | Gross Irrigation Requirements(m3/ha) Wheat | Barley | Potato |
|---|---|---|---|---|
| Kohkiloye | 54.1 | 6317 | 4867 | 12356 |
| Kerman | 40.5 | 10651 | 8009 | 15077 |
| Chaharmahal | 30 | 10927 | 8662 | 14860 |
| Khozestan | 44.1 | 6616 | 5134 | 9220 |
| Khorasan-Jounoubi | 35 | 11228 | 9866 | 27238 |
| Esfehan | 39.5 | 11478 | 9588 | 17561 |
| Lorestan | 40 | 6931 | 5230 | 18196 |
| Ghom | 35 | 7082 | 5303 | 19751 |
| Markazi | 50.4 | 7534 | 5757 | 17955 |
| Hamedan | 45.6 | 7055 | 5533 | 16973 |
| Tehran | 44.1 | 6049 | 5020 | 15641 |
| Kordestan | 40 | 6445 | 4800 | 15322 |
| Ghazvin | 52.3 | 6981 | 5613 | 15481 |
| Mazandaran | 51.2 | 3678 | 3010 | 9993 |
| Semnan | 41.3 | 7275 | 6345 | 16118 |
| Zanjan | 35.7 | 8832 | 6979 | 17647 |
| Khorsan-Razavi | 42.7 | 10301 | 8893 | 23238 |
| Golestan | 41.9 | 5115 | 4115 | 11208 |
| Khorasan-Shomali | 35 | 7215 | 6165 | 18276 |
| Ardebil | 64.8 | 4588 | 3404 | 10382 |
| Azarbayjan Gharbi | 51.3 | 5450 | 3957 | 12282 |
| Gilan | 47 | 4624 | 3590 | 8642 |
| Boshehr | 40 | 6041 | 4903 | 8041 |
| Azerbayjan Sharghi | 43.5 | 6539 | 4835 | 14317 |
| Fars | 50.3 | 8323 | 6806 | 11550 |
| Hormozgan | 37 | 6337 | 5496 | 16065 |
| Yazd | 47.2 | 12104 | 10070 | 17666 |
| Kermanshah | 42.4 | 5660 | 4269 | 17753 |
| Ilam | 35 | 6839 | 5298 | 14398 |
| Sistam | 35 | 8973 | 7228 | 17537 |
| Mean | 46.1 | 7439.60 | 5958.17 | 15358.13 |

Table 2 shows the gross value, total production costs, gross benefit, person–day–work, laborers' costs and added value of products per hectare of cultivation of the three crops in million Rials in the provinces under study. All the relevant values of the crops from table 1 and 2 were inserted into descriptive table of Iran map divided by each province using ArcGIS10 software and then were interpolated using Inverse Distance Weighted (IDW) method. Then the raster map was extracted based on the mentioned amounts of crops throughout Iran including all parts. Later, the raster maps of the geographical distribution of different water use productivity indexes in Iran were prepared using overlay of the existing maps per formula of each index.

The final maps were the result of different maps of water use productivity indexes for the three crops using stretched classification where the scope of changes and the maximum and minimum of the mentioned indexes are well marked on this classification and are presented at the end of the relevant maps as far as wheat as an example is concerned (Fig 1, 2 and 3).

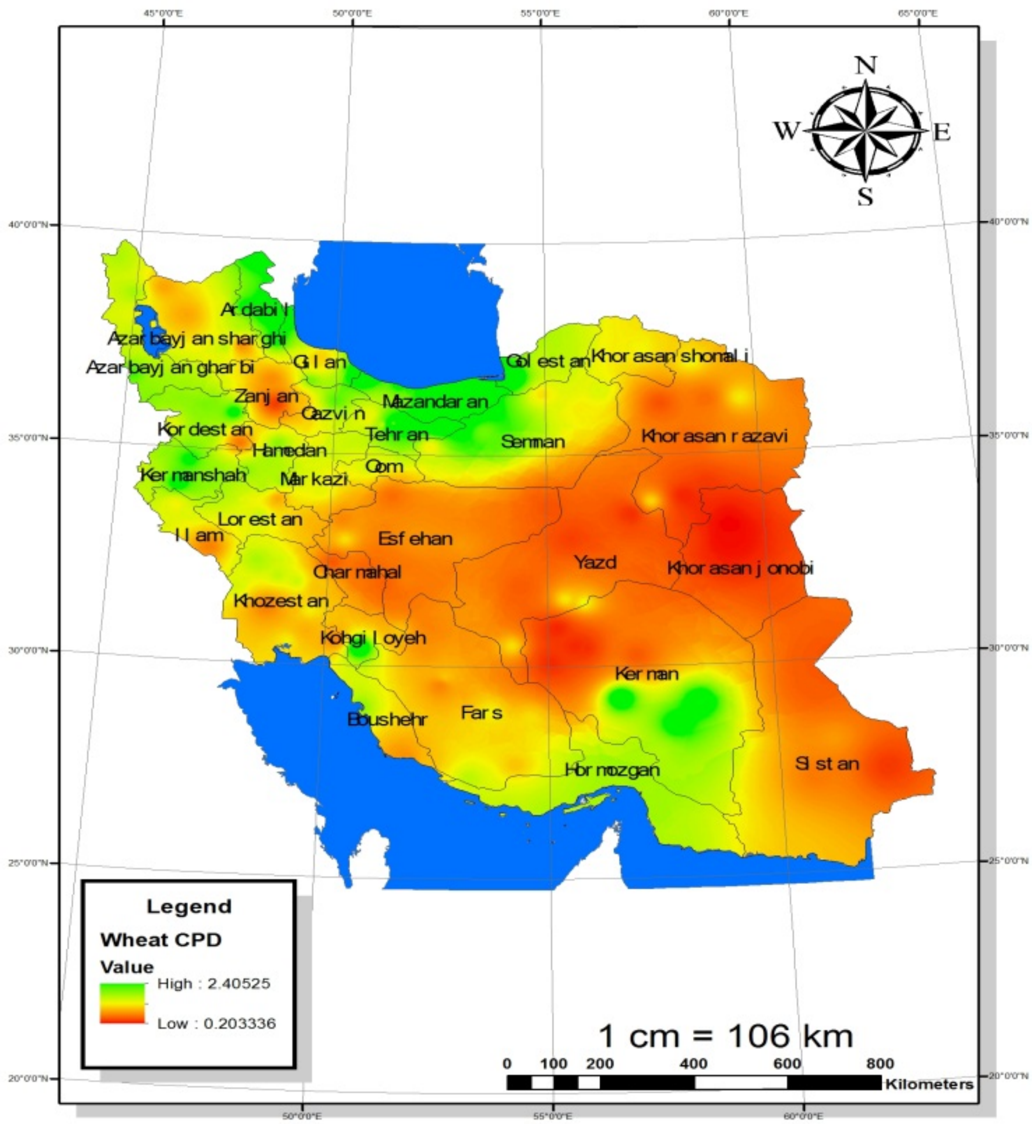


Fig. 1. Spatial distribution of CPD index per Kg/m3 for Wheat

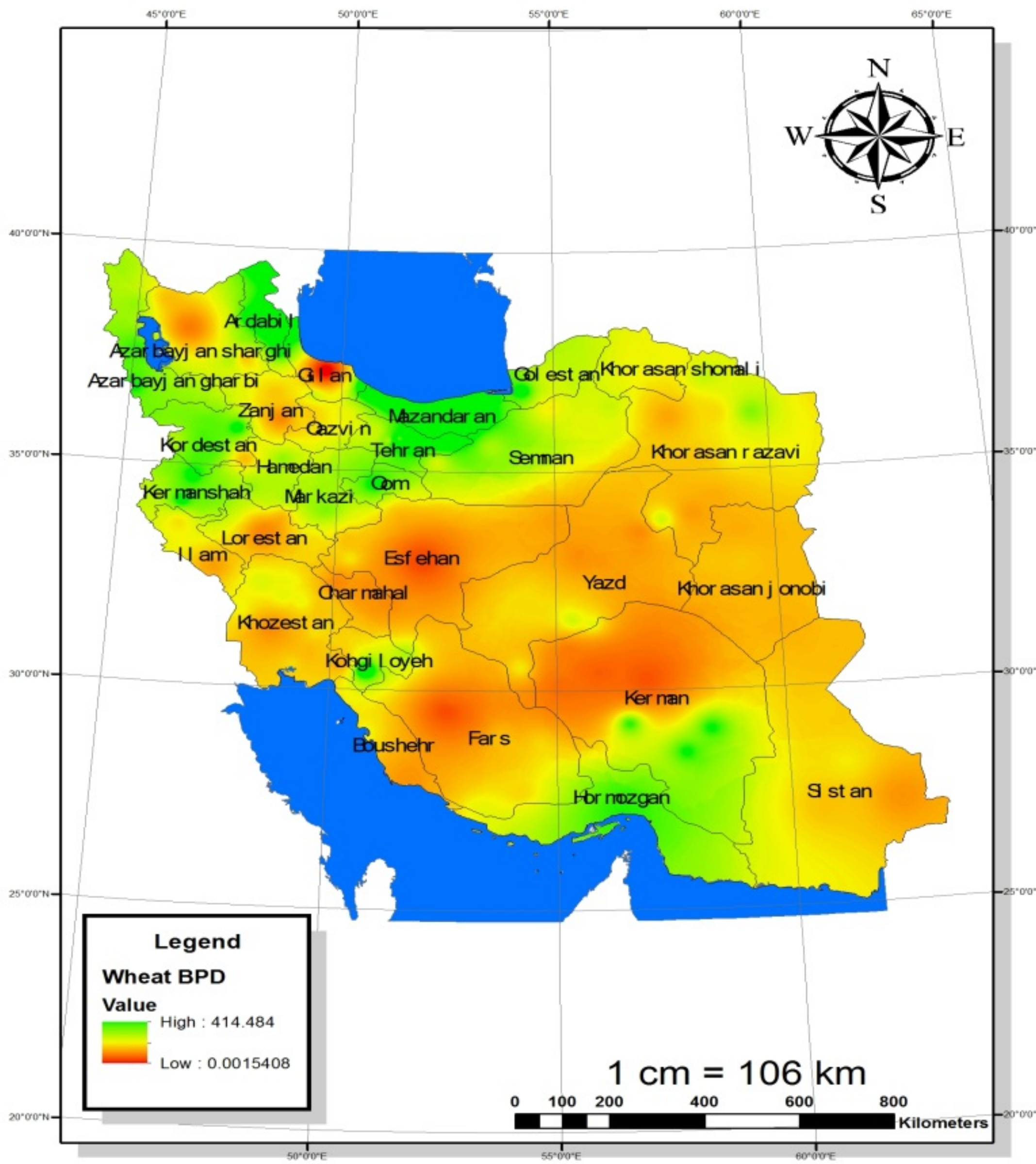


Fig. 2. Spatial distribution of BPD index per 10 Rials/m3 for Wheat

Eventually taking into consideration the gained indexes as an average according to each province, table 3 which is the final result of the study in hand was established where the figures of each province as the average of each gained productivity rate of that province are enumerated to be used by the researchers and experts.

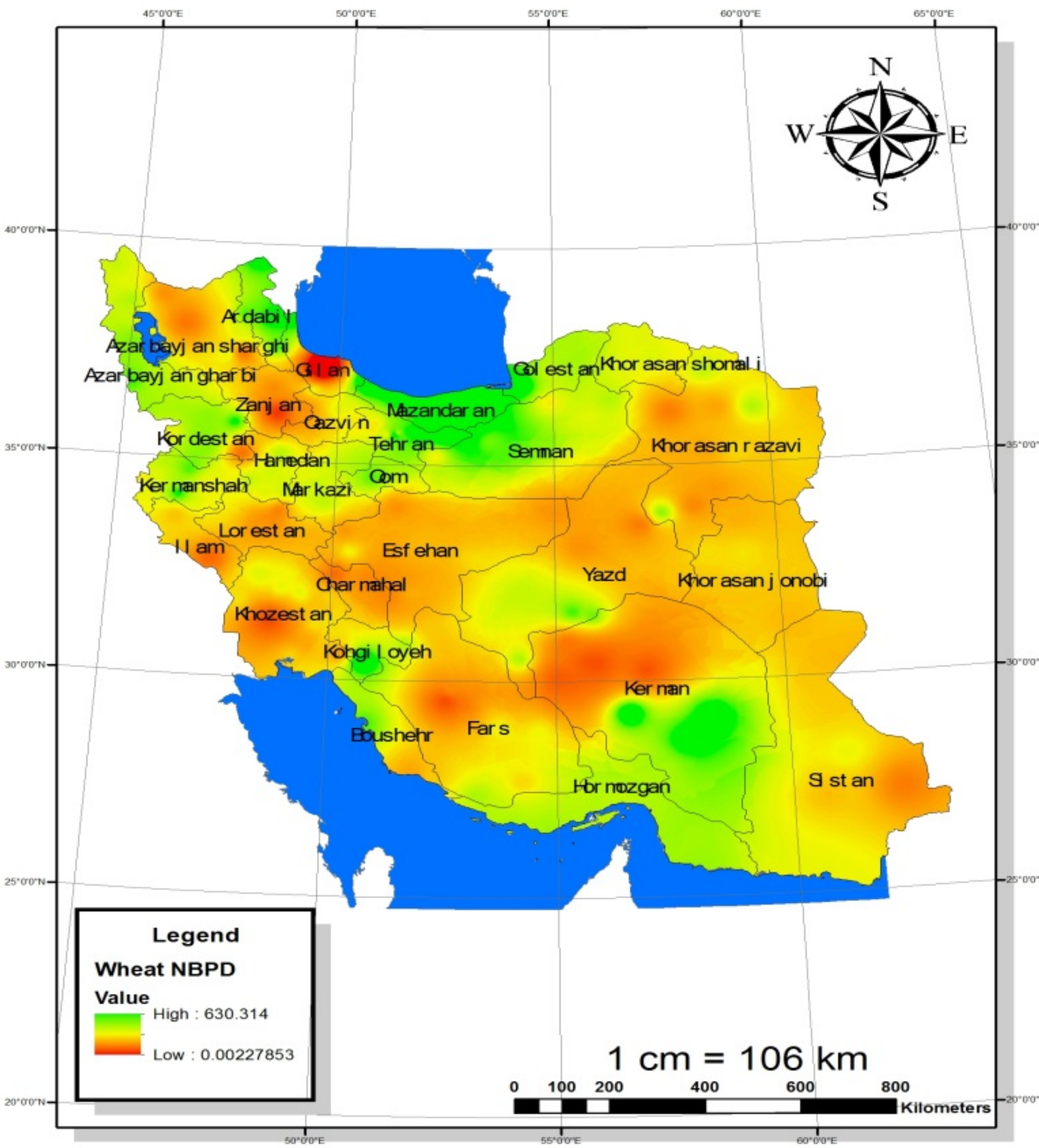


Fig. 3. Spatial distribution of NBPD index per 10 Rials/m$^3$ for Wheat

## 3. Results and Discussion

Considering the gained maps, it was found that the highest productivity of wheat in Iran (CPD) is 2.4 (kg/m3) in Khuzestan province, while it is 0.2 in South Khorasan province. Comparison with NBPD index shows that Khuzestan province had the highest rate of productivity and talent to farm wheat.

As far as barley is concerned, the highest productivity in CPD is 9.89 which is located in Khorasan Razavi province and is quite high and suitable in comparison with the international index which is 1.8 to 2. The lowest productivity is 0.25 (kg/m3) in South Khorasan province and the average productivity level is lower in other parts of Iran. The north, east and central parts show the required talent for farming and eventually NBPD index in Yazd province shows the best value as far as BPD index is concerned.

Potato shows the highest productivity equal to 19.01 (kg/m3) in Hamedan province and is the highest among the other two crops as far as the highest productivity rate is concerned. The high productivity justifies its farming despite being costly. There is a high potential to produce this crop in Kerman province, and Gilan and Mazandaran provinces stand the next. The east and northeast parts of Iran are not suitable for this purpose.

As it is noticed in table 3, potato has the highest productivity of water as far as the four BPD, CPD, NBPD and B/C indexes are concerned in all provinces and this shows that although potato is a costly crop in the production process, its high productivity according to all indexes turns it to a productive and economical crop.

The total average amounts of water use productivity of wheat, barley and potato in Iran are 0.54, 0.91 and 1.62, respectively. Even potato that has the highest productivity is very low in comparison with the international productivity index which is 1.8 to 2 (kg/m3).

Comparison between the rates of water use productivity indexes of the crops under study and international figures shows that the range of changes of productivity indexes of agricultural products in Iran is very vast. The maximum amounts of these indexes provide a view of the productivity potential of the crops that could also increase through improvement of management solutions and methods. The minimum amounts also show the status of water use productivity in traditional farming without applying management methods and efficient irrigation systems.

Generally speaking, BPD index has higher precision in comparison with CPD index, but is incomplete because it does not take the production costs into consideration. NBPD index has a higher economic precision in comparison with the other two indexes. Benefit per cost index could also indicate productivity of water because the costs of irrigation water supply are included in the production costs, but this index is mainly considered from macro-economy point of view.

Since any of the mentioned indexes have their own advantages, selection of an index as the superior index is difficult and each of the indexes could be used considering the conditions, needs and policies of each region and province of the country, holding and gaining the indexes and mixing their results together.

## 4. Conclusions

Generally speaking, CPD index is used more often than other water use productivity indexes due to being simpler. This index is usually used in calculations, while the other indexes are less noted. Hence it is suggested to pay special attention to this issue in the conducted studies and/or in the future studies as different water use productivity indexes are likely to have different results.

One of the most comprehensive and complete productivity indexes is NBPD which is used less often due to its difficult calculation process, but it could have more acceptable and realistic results, if used due to being comprehensive and that is why this index is suggested to be used more often.

Table 2. Performance, Gross value, Total cost of production, Gross benefit, Person-Day-Work, labor costs and value added per acre in Wheat, Barley and Potato

| Province | Wheat | | | | | | | Barley | | | | | | | Potato | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Performance (Kg ha) | Gross value (Million Rial) | Total cost of production | Gross Benefit (Million Rial) | Person-Day work | labor costs (Million Rial) | value added (Million Rial) | Performance (Kg ha) | Gross value (Million Rial) | Total cost of production | Gross Benefit (Million Rial) | Person-Day work | labor costs (Million Rial) | value added (Million Rial) | Performance (Kg ha) | Gross value (Million Rial) | Total cost of production | Gross Benefit (Million Rial) | Person-Day work | labor costs (Million Rial) | value added (Million Rial) |
| Kohkiloye | 2874.70 | 13.00 | 7.16 | 5.84 | 31.55 | 4.10 | 9.94 | 3131.40 | 8.17 | 5.97 | 2.20 | 24.82 | 3.22 | 5.42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kerman | 5972.60 | 20.91 | 16.78 | 4.13 | 72.43 | 9.41 | 13.54 | 4568.20 | 15.05 | 15.31 | -0.26 | 69.58 | 9.04 | 8.77 | 53898.3 | 101.4 | 56.1 | 45.3 | 157.6 | 20.5 | 65.8 |
| Chaharmahal | 3831.50 | 13.13 | 8.47 | 4.66 | 45.51 | 5.91 | 10.57 | 3282.60 | 11.76 | 8.39 | 3.37 | 42.41 | 5.51 | 8.88 | 30980.9 | 48.8 | 22.5 | 26.3 | 63.9 | 8.3 | 34.6 |
| Khozestan | 2606.00 | 7.51 | 4.70 | 2.80 | 14.20 | 1.84 | 4.65 | 1869.10 | 4.07 | 2.70 | 1.37 | 7.68 | 1 | 2.37 | 23959.8 | 41.6 | 24.6 | 16.9 | 41.9 | 5.4 | 22.4 |
| Khorasan-Jounoubi | 2192.00 | 15.33 | 9.66 | 5.67 | 53.24 | 6.92 | 12.59 | 2699.40 | 13.11 | 7.78 | 5.33 | 48.01 | 6.24 | 11.57 | 13728.7 | 17.7 | 23.6 | -5.9 | 172.9 | 22.5 | 16.5 |
| Esfehan | 4573.90 | 12.97 | 10.98 | 1.98 | 81.66 | 10.61 | 12.59 | 4360.80 | 12.60 | 10.94 | 1.66 | 76.28 | 9.91 | 11.57 | 23982.5 | 46.8 | 28.2 | 18.6 | 122.6 | 15.9 | 34.5 |
| Lorestan | 3225.30 | 8.28 | 6.41 | 1.87 | 24.13 | 3.13 | 5.00 | 2892.10 | 8.75 | 6.95 | 1.80 | 22.12 | 2.87 | 4.67 | 34240.6 | 66.4 | 28.1 | 38.3 | 46.7 | 6.1 | 44.4 |
| Ghom | 3403.90 | 15.98 | 7.91 | 8.07 | 23.13 | 3.00 | 11.07 | 32521.60 | 9.78 | 7.89 | 1.89 | 22.73 | 2.95 | 4.84 | 6608.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Markazi | 3861.70 | 13.35 | 5.94 | 7.41 | 24.04 | 3.12 | 10.53 | 4378.00 | 11.78 | 6.81 | 4.96 | 27.08 | 3.52 | 8.48 | 25022.3 | 53.2 | 16.7 | 36.5 | 52.2 | 6.8 | 43.3 |
| Hamedan | 4394.10 | 14.16 | 8.03 | 6.13 | 26.37 | 3.43 | 9.55 | 4852.60 | 10.73 | 8.14 | 2.59 | 24.16 | 3.14 | 5.73 | 42262.1 | 79.7 | 36.8 | 43 | 69.7 | 9.1 | 52 |
| Tehran | 5433.80 | 16.76 | 8.53 | 8.23 | 23.49 | 3.05 | 11.28 | 4411.10 | 11.61 | 8.87 | 2.75 | 26.78 | 3.48 | 6.23 | 29301.5 | 52.5 | 38.9 | 13.5 | 146.9 | 19.1 | 32.6 |
| Kordestan | 4475.60 | 14.14 | 5.98 | 8.16 | 26.65 | 3.46 | 11.62 | 4646.40 | 9.77 | 5.28 | 4.49 | 13.68 | 1.78 | 6.27 | 32269.7 | 66.2 | 33.4 | 32.7 | 82.7 | 10.7 | 43.5 |
| Ghazvin | 4252.30 | 14.99 | 11.12 | 3.87 | 26.65 | 3.46 | 7.33 | 4269.10 | 11.98 | 10.85 | 1.12 | 36.56 | 4.75 | 5.87 | 17959.7 | 50.3 | 24.3 | 25.9 | 117.3 | 15.2 | 41.2 |
| Mazandaran | 2903.70 | 14.32 | 5.09 | 9.23 | 22.66 | 2.94 | 12.18 | 2727.20 | 5.93 | 3.41 | 2.52 | 39.46 | 5.13 | 7.65 | 13980.4 | 43.4 | 24 | 19.5 | 104.2 | 13.5 | 33 |
| Semnan | 4593.60 | 13.00 | 7.16 | 5.84 | 42.72 | 5.55 | 11.39 | 4047.60 | 10.54 | 6.65 | 3.89 | 32.84 | 4.27 | 8.16 | 19641 | 61.5 | 22.8 | 38.7 | 57.3 | 7.4 | 46.2 |
| Zanjan | 3627.70 | 12.73 | 7.34 | 5.39 | 25.01 | 3.25 | 8.64 | 3089.30 | 10.94 | 6.12 | 4.82 | 23.78 | 3.09 | 7.91 | 25772.6 | 63.6 | 28.8 | 34.8 | 43.8 | 5.7 | 40.5 |
| Khorsan-Razavi | 3526.60 | 13.91 | 6.65 | 7.26 | 28.10 | 3.65 | 10.91 | 3702.40 | 11.76 | 5.73 | 6.03 | 26.3 | 3.42 | 9.44 | 29332 | 58.1 | 26.9 | 31.2 | 203.8 | 26.5 | 57.7 |
| Golestan | 3054.90 | 11.30 | 7.58 | 3.71 | 27.46 | 3.57 | 7.28 | 4134.50 | 8.79 | 5.96 | 2.83 | 3.41 | 0.44 | 3.28 | 24013.3 | 40.5 | 24.5 | 16 | 72.5 | 9.4 | 25.4 |
| Khorasan-Shomali | 3565.70 | 12.31 | 7.47 | 4.84 | 35.63 | 4.63 | 9.46 | 3696.60 | 10.20 | 6.76 | 3.44 | 39.37 | 5.11 | 8.56 | 17909.2 | 97.5 | 31.9 | 65.6 | 125.1 | 16.3 | 81.8 |
| Ardebil | 4112.20 | 14.76 | 6.88 | 7.88 | 8.39 | 1.09 | 8.97 | 2948.40 | 7.72 | 4.70 | 3.01 | 6.88 | 0.89 | 3.91 | 25701.2 | 49.8 | 30.7 | 19.2 | 58.2 | 7.6 | 26.7 |
| Azarbayjan Gharbi | 3086.60 | 12.78 | 6.36 | 6.41 | 20.57 | 2.67 | 9.09 | 2443.30 | 8.96 | 5.89 | 3.07 | 16.29 | 2.12 | 5.18 | 20640.3 | 33.6 | 21.8 | 11.8 | 99.3 | 12.9 | 24.7 |
| Gilan | 2163.90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2884.00 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 20218.1 | 37.8 | 18.2 | 19.6 | 94.3 | 12.2 | 31.8 |
| Boshehr | 2493.20 | 8.54 | 6.12 | 2.42 | 35.69 | 4.64 | 7.06 | 1864.60 | 8.43 | 6.14 | 2.29 | 36.23 | 4.71 | 7 | 9285.1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Azerbayjan Sharghi | 3013.10 | 10.01 | 7.65 | 2.36 | 26.72 | 3.47 | 5.83 | 3253.50 | 6.71 | 5.76 | 0.95 | 23.47 | 3.05 | 4 | 33065.1 | 70.1 | 31.2 | 38.9 | 99.2 | 12.9 | 51.8 |
| Fars | 3895.00 | 11.06 | 9.10 | 1.96 | 38.44 | 4.99 | 6.96 | 2795.10 | 6.74 | 7.22 | -0.48 | 44.27 | 5.75 | 5.27 | 25571.1 | 27.9 | 20.8 | 7.1 | 65.9 | 8.6 | 15.6 |
| Hormozgan | 3914.20 | 15.19 | 7.56 | 7.63 | 11.08 | 1.44 | 9.06 | 2153.00 | 5.15 | 5.13 | 0.02 | 15.68 | 2.04 | 2.06 | 28784.4 | 11.5 | 10 | 1.5 | 48.2 | 6.3 | 7.8 |
| Yazd | 3679.20 | 17.20 | 9.56 | 7.64 | 84.91 | 11.03 | 18.67 | 3484.60 | 11.18 | 8.30 | 2.88 | 7832 | 1017.38 | 1020.25 | 20509.6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kermanshah | 4020.40 | 12.71 | 6.36 | 6.35 | 7.39 | 0.96 | 7.31 | 4763.20 | 0.00 | 0.00 | 0.00 | 0 | 0 | 0 | 11306.2 | 17.9 | 21.4 | -3.5 | 26.6 | 3.5 | 0 |
| Ilam | 3181.70 | 9.88 | 6.12 | 3.76 | 21.10 | 2.74 | 6.50 | 2611.10 | 2.99 | 2.28 | 0.71 | 6.82 | 0.89 | 1.6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sistam | 2406.2 | 9.33 | 4.58 | 4.74 | 35.56 | 4.62 | 9.36 | 2045.3 | 6.99 | 4.4 | 2.59 | 27.14 | 3.53 | 6.11 | 30079.9 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 3. Average of different indicators of water use productivity from GIS maps for Wheat, Barley and Potato

| Province | Wheat | | | | Barley | | | | Potato | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | CPD (Kg/m3) | BPD (10Rials/m3) | NBPD (10Rials/m3) | B/C | CPD (Kg/m3) | BPD (10Rials/m3) | NBPD (10Rials/m3) | B/C | CPD (Kg/m3) | BPD (10Rials/m3) | NBPD (10Rials/m3) | B/C |
| Kohkiloye | 0.54 | 81.88 | 161.05 | 0.8158 | 0.81 | 48.39 | 693.07 | 0.37 | 0.97 | 67.41 | 93.4 | 0 |
| Kerman | 0.48 | 60.02 | 132.79 | 0.2463 | 0.48 | 17.01 | 1197.62 | -0.02 | 2.48 | 139.13 | 222.23 | 0.81 |
| Chaharmahal | 0.34 | 43.06 | 92.91 | 0.5503 | 0.47 | 32.97 | 255.31 | 0.40 | 1.71 | 143.68 | 192 | 1.17 |
| Khozestan | 0.47 | 56.29 | 105.32 | 0.5964 | 0.67 | 36.84 | 158.07 | 0.51 | 2.6 | 210.45 | 273.97 | 0.69 |
| Khorasan-Jounoubi | 0.25 | 49.15 | 108.39 | 0.587 | 0.3 | 42.47 | 446.78 | 0.69 | 0.74 | 16.41 | 83.81 | -0.25 |
| Esfehan | 0.35 | 43.28 | 101.74 | 0.1804 | 0.67 | 26.49 | 977.27 | 0.15 | 1.24 | 103.29 | 154.8 | 0.66 |
| Lorestan | 0.52 | 58.66 | 103.32 | 0.2911 | 0.82 | 39.04 | 89.36 | 0.26 | 1.47 | 151.5 | 184.78 | 1.37 |
| Ghom | 0.53 | 104.68 | 153.47 | 1.0199 | 4.33 | 44.71 | 129.71 | 0.24 | 0.74 | 54.43 | 80.7 | 0 |
| Markazi | 0.52 | 88.86 | 133.16 | 1.2487 | 1.7 | 56.7 | 117.86 | 0.73 | 1.3 | 147.24 | 188.5 | 2.18 |
| Hamedan | 0.59 | 84.25 | 128.93 | 0.7628 | 0.97 | 47.3 | 98.91 | 0.32 | 1.94 | 200 | 248.5 | 1.17 |
| Tehran | 0.78 | 122.36 | 181.56 | 0.965 | 1.43 | 54.38 | 131.67 | 0.31 | 1.5 | 119.47 | 208.76 | 0.35 |
| Kordestan | 0.65 | 105.63 | 153.44 | 1.3649 | 0.92 | 72.74 | 115.95 | 0.85 | 1.95 | 196.66 | 261 | 0.98 |
| Ghazvin | 0.58 | 70.83 | 115.58 | 0.3482 | 0.95 | 34.03 | 102.8 | 0.10 | 1.39 | 167.82 | 250.24 | 1.07 |
| Mazandaran | 1.11 | 192.5 | 298.77 | 1.8141 | 1.75 | 100.64 | 241.82 | 0.74 | 2.18 | 242 | 371.15 | 0.81 |
| Semnan | 0.57 | 81.25 | 151.99 | 0.8158 | 0.88 | 53.84 | 666.36 | 0.59 | 1.31 | 175 | 241.33 | 1.70 |
| Zanjan | 0.43 | 61.64 | 94.85 | 0.7345 | 0.58 | 51.02 | 91.55 | 0.79 | 1.49 | 175 | 224.71 | 1.21 |
| Khorsan-Razavi | 0.34 | 61.72 | 109.62 | 1.0921 | 0.46 | 53.63 | 446.44 | 1.05 | 1.04 | 125.12 | 212.8 | 1.16 |
| Golestan | 0.68 | 91.34 | 170.95 | 0.4895 | 1.15 | 77.89 | 250.66 | 0.48 | 2 | 233.26 | 335.84 | 0.65 |
| Khorasan-Shomali | 0.5 | 69.94 | 109.62 | 0.6469 | 0.46 | 56.62 | 265.18 | 0.51 | 1.05 | 303.22 | 390.4 | 2.05 |
| Ardebil | 0.84 | 141.28 | 179.66 | 1.1455 | 1.03 | 79.92 | 127.08 | 0.64 | 2.47 | 219.74 | 306.32 | 0.63 |
| Azarbayjan Gharbi | 0.62 | 100.44 | 151.01 | 1.0083 | 0.78 | 65.5 | 122.06 | 0.52 | 2.01 | 181.11 | 272.28 | 0.54 |
| Gilan | 0.7 | 76.24 | 107.59 | 0 | 1.04 | 43.23 | 250.66 | 0 | 2.55 | 262 | 396.35 | 1.07 |
| Boshehr | 0.5 | 52.28 | 134.66 | 0.3957 | 0.55 | 39.66 | 543.46 | 0.37 | 1.78 | 53.23 | 85.25 | 0 |
| Azerbayjan Sharghi | 0.52 | 70.09 | 112.54 | 0.3083 | 0.69 | 43.05 | 93.65 | 0.17 | 1.96 | 203.28 | 281.31 | 1.24 |
| Fars | 0.44 | 50.14 | 113.13 | 0.2157 | 0.47 | 15.48 | 999.81 | -0.07 | 1.95 | 74.72 | 131.84 | 0.34 |
| Hormozgan | 0.61 | 100.07 | 154.33 | 1.0081 | 0.46 | 12 | 708.71 | 0 | 1.77 | 42.63 | 88.55 | 0.15 |
| Yazd | 0.31 | 49.04 | 114.67 | 0.7992 | 0.42 | 27.45 | 3698.86 | 0.35 | 1.35 | 69.84 | 118.29 | 0 |
| Kermanshah | 0.69 | 103.29 | 142.86 | 0.9977 | 1.04 | 33.17 | 59.19 | 0 | 0.92 | 62.26 | 90 | -0.16 |
| Ilam | 0.51 | 63.55 | 105.06 | 0.6154 | 0.69 | 24.91 | 54.62 | 0.31 | 1 | 90.46 | 114.87 | 0 |
| Sistam | 0.36 | 58.44 | 117.67 | 1.0349 | 0.36 | 30.3 | 626.12 | 0.59 | 1.85 | 49.72 | 91.66 | 0 |
| Mean | 0.54 | 79.74 | 134.69 | 0.74 | 0.91 | 45.38 | 458.69 | 0.40 | 1.62 | 142.67 | 206.52 | 0.72 |

It is very useful to use and apply productivity indexes, especially NBPD index to organize farming patterns due to the farmers' economic justification. This index is concentrated on net benefit and since the farmers' aim is to gain the maximum benefit, it is very understandable and justifiable for them and could help the farmers reach their main aim which is gaining more benefit. This defines the above index in the best possible way.

Comparing the water use productivity indexes with the realities of the country and the current farming pattern of crops, it is concluded that in some regions the current farming pattern does not correspond with the crops productivity in that region and that a crop which is farmed in the region is not suitable for it considering its current productivity rate. It is concluded that changing the farming pattern of the region could result in optimizing the production output which is the main objective of the study in hand.

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