International Journal of Agricultural Management and Development (IJAMAD)
Available online on: www.ijamad.com
ISSN: 2159-5852 (Print)
ISSN:2159-5860 (Online)

Comparative –Analytical Study of Economic Productivity of Water between Smallholding and Rural Production Cooperative Utilization System

Mohammad Reza Bakhshi [1*], ***Behnaz Nejati*** [2] ***and Mofid Shateri*** [3]

Received: 7 May 2014,
Accepted: 17 August 2014

Abstract

In recent years, farming section of South Khorasan Province faces different limitations such as increasing shortage of water resources and continuous reduction of weather showers. Considering consecutive droughts and water crisis in agricultural plain of the province, it is necessary to use water resources optimally and increase productivity of water shortage input. Comparison of water productivity among the available utilization systems in agricultural section of the province can cause recognition of suitable and efficient utilization system for optimal use of water shortage input and increase water productivity in production of crops. In the present research, different indices of water productivity for production of crops in two small holding utilization system and Rural Production Cooperative in Khosef County have been calculated and compared. The required data have been collected with a sample of 247 farmers and with two-staged cluster sampling and with questionnaire. To calculate and compare water productivity, Benefit Per Drop, Crop Per Drop and Net Benefit Per Drop indices have been used. Results showed that the said indices were different for similar products in two utilization systems and in most crops, the said indices in rural production cooperative system were higher than small holding system. Therefore, gathering of smallholder's farmers as rural production cooperative can lead to more desirable utilization of water resources and reduction of drought effects and water crisis.

Keywords:
Farming, Utilization system, Cooperative, Water, Economic productivity

[1] Associate professor of Agronomy Department, Faculty of Agriculture,University of Birjand.
[2] Former Graduate Student Department of Geography, Faculty of Literature and Humanities, University of Birjand.
[3] Associate professor of Department of Geography, Faculty of Literature and Humanities, University of Birjand.
* Corresponding author's email: mbakhshi@birjand.ac. and irmbakhshi@birjand.ac.ir

INTRODUCTION

Today, drought and water resources shortage are regarded as important issue and one of the constraints of farming section. Due to recent droughts, South Khorasan Province is ranked 24 in terms of rainfall and on top of the drought pyramid of the country (South Khorasan Province Agricultural Jihad Organization, 2009). Agricultural section plays important role in economy of the province and particularly in rural regions of the province and life of people is dependent on it. Now, when drought and water shortage occur, water input shortage increases and water has special and important place among the resources and production inputs and perhaps, water can be regarded as the most important production source in farming. Therefore, improvement of water productivity in production of crops is mentioned as the main agricultural issue in the future. Under such conditions, it is necessary to conduct extensive and effective researches for evaluation and study of the condition of using water and optimality of this input and based on suitable strategies to increase productivity of supply and consumption of this rare and valuable input (Ghasemian and Eshraghi, 2012).

Goal of increasing water productivity in farming is to maximize profit of water resources consumption in farming section. Therefore, limited water resources of the country should be allocated to the crops which have higher return for each cubic meter of water to obtain higher productivity in farming section. Although this issue cannot mean negligence of other long-term goals such as food security and employment, it is necessary to consider financial and economic efficiency to increase productivity beside these goals (Zeid Ali *et al*., 2008). Increase of productivity increases production in surface area on the one hand and reduces production costs and cost price of the product on the other hand (Ghasemian and Eshraghi, 2012). Utilization systems always play important role in application of production factors and increase of input productivity such as water shortage inputs. Variety of utilization systems in farming section caused different water productivity in production of crops. Therefore, comparison of water productivity in different utilization systems can cause recognition of suitable and efficient utilization system in water consumption and increase its productivity in production of crops.

Based on importance of water input in production of crops, water productivity measurement has been studied very much inside and outside the country. Poor Sani *et al.* (2008) in a research entitled “analyzing indices of agricultural water productivity in a rural production cooperative” studied indices of BPD and NBPD in a rural production cooperative in Kerman Province. The obtained results indicate promotion of these indices by performing infrastructural operations and they can be used in major planning of this section, selection of cultivation pattern, irrigation method and analysis of economic value of water for production. Rohani (2005) in a research compared water productivity in farmlands of the member and non-member farmers of Hamedan Province rural production cooperatives. The obtained results show that mean water productivity for the crops is almost equal in member utilizations of rural production cooperatives and non-member utilizations and membership in production cooperative has no effect on water productivity. Zwart and Bastiaanssen (2004) in a research studied physical productivity of water input in production of wheat, rice, cotton and corn crops in different countries. Based on results of this research, mean physical productivity of water for the mentioned crops are 1.09, 1.09, 0.65, 0.23, and 1.80 kg/m^3. Henry *et al.* (2006) estimated physical productivity of water to be between 0.4 and 0.70 kg/m^3 for corn in Tanzania by performing farm experiments. Eshraghi and Ghasemian (2012) in a study calculated and evaluated water economic productivity in production of important crops in counties of Golestan province such as cotton, rapeseed, soy and rice with water productivity indices. Results of the research showed that the highest economic productivity of water has been 134960 Rials/m^3 of water for cotton in Gonbad Kavoos, 5620 Rials/m^3 of water for rapeseed in Agh Ghola, 3940 Rials/m^3 of water for summer soy, 21080 Rials/m^3 of water for high quality long grain rice, 9880 Rials/m^3 of water for fruitful rice in Ali Abad and 9600 Rials/m^3 of water for medium grain rice in Kalaleh. Cai *et al.* (2003) in a research measured physical and economic efficiency of water consumption in agricultural areas around a river in Chile and show that both types of the said efficiency in farmlands with pressurized irrigation systems have significant difference from other farmlands. Liu *et al.* (2008) have calculated and reported water physical productivity in corn for 124 countries. Findings of this research show that the highest physical productivity of water relating to America and China is 1.5 kg/m^3 of water and the lowest value relating to African countries is below 1 kg/m^3 of water. Sanei and Hassan Poor (2009) analyzed water productivity in irrigation and drainage system in Khoozestan with CPD and BPD indices and suggested that corn should be excluded from the available cultivation pattern and barley crop should be included to improve water consumption productivity. Soltani *et al.* (2007) studied agricultural water productivity in Marvdasht –Karbal. Results showed that cultivations with high water consumption and low economic return such as sugar beet should be excluded from cultivation pattern of the region and some cultivations such as forage maize or one-year period of native cultivations such as wheat and barley and vegetables such as tomato which decrease water consumption and also create high economic benefits for the farmers and agricultural users should be used. Results of study by Singh *et al.* (2006) on physical productivity of water for wheat, rice and cotton in the country show that there is significant difference between physical productivity of the above products so that physical productivity of wheat is four times as much as the cotton. Based on results of this study, physical productivity of the said crops is equal to 1.04, 0.84 and 0.21 kg/m^3 of water. Zeid Ali *et al.* (2008) evaluated and compared water productivity in three sections of Moghan agro-industry, Pars agro-industry and private section lands. Results of this research showed that average indices of CPD, BPD, and NBPD in private section lands are better than irrigation and drainage system of Moghan and Pars agro-industry.

Studies show that water productivity in different time periods and regions are different from each other and are affected by production method and production region and generally, type of utilization system. On this basis, the present research has compared agricultural water productivity in common crops of two smallholding and Rural Production Cooperative Utilization systemin Khosef County located in South Khorasan Province. The main hypothesis of this research is that different indices of water productivity are different in production of crops between utilization systems and water consumption can be reduced and aquifer of the studied zone has been empowered through policymaking for expansion of utilization system by identifying utilization system with higher water input productivity for production of common crops of the region.

MATERIALS AND METHODS

Agricultural water productivity measurement and analysis have special position in Iran due to quantitative and qualitative limitations of this valuable substance. Productivity is related to the extent and manner of using inputs or production factors in a specific production process, definite period and specified geographical zone to achieve the determined goals (Ehsani and Khaledi, 2003). Productivity generally means ratio of outputs to inputs. In other words, productivity means average production for each unit of total inputs. So, if average production increases for each unit of inputs, productivity will increase and vice versa. To calculate productivity considering type of the input which is applied in production process, types of productivity indices can be defined. Generally, productivity indices are divided into two partial productivity indices and whole productivity indices of production factors (Vali Zadeh, 2005). Productivity index indicates ratio of production volume or value to one or more factor value which has been used for producing it. In other words, any relationship between output and data as ratio is productivity index. Indices have different types and application of each one of them depends on goal of the research. In this research, considering the mentioned goals and hypotheses, CPD (Crop Per Drop), BPD (Benefit Per Drop) and NBPD (Net Benefit Per Drop) indices have been used:

$$CPD = Y(kg)/W(m^3) \tag{1}$$

$$BPD = P_{y*}Y(kg)/W(m^3) \tag{2}$$

$$BPd = p_{y*}(kg)\text{-}TC/W(m^3) \tag{3}$$

Where, Y is quantity of crop, W is water consumption, Py is price of each crop unit and TC is total cost of production. Relation (1) shows that consumption of each m^3 of water obtains some kilograms of crop. This index has evaluated physical productivity of water from agricultural viewpoint and higher index for a crop indicates higher physical productivity in production of that crop. BPD and NBPD indices which are applied in economic analyses have paid attention to economic and monetary aspect of water in addition to physical aspects and measure economic productivity of water. The said indices show how much Rial value has been created for each m^3 of water. According to Relation (3), any product which can have higher net earning with lower consumption of water will have higher economic productivity (Ehsani and Khaledi, 2003, Liu *et al.*, 2008; Henry *et al.*, 2006). These indices can be calculated for comparison of a type of definite crop in different regions or for a special region (farmland) over time. In other words, these indices can be applied for an external or interregional comparison (between farmlands) and also for an internal comparison (time trend) (Ehsani and Khaledi, 2003). In this research, all three induces have been calculated and analyzed from both agricultural and economic viewpoints to compare water productivity among the crops.

Statistical population of the present research includes farmers of Khosef county located in South Khorasan Province. Khosef plain has been regarded as one of the important agricultural poles of South Khorasan Province and farming as one of the important economic sections plays considerable role in employment and earning living in Khosef county. The most important crops of this county include wheat, barley, alfalfa and beet (South Khorasan Province Agricultural Jihad Organization, 2009). The studied scope has smallholding, rural production cooperative and agro-industry utilization systems. Considering that the prevailing systems in this county are smallholding and rural production cooperative utilization systems, this research has compared agricultural water productivity of common crops of two utilization systems in the studied zone.

The data used in the present research has been obtained with questionnaire and interview with farmers. In this research, crops production cost questionnaire which has been prepared by Ministry of Agriculture and is used every year in crops statistics has been used with some alterations. The questionnaire has been prepared by the agricultural experts and have suitable validity and reliability considering its use in the consecutive years. Statistical sample size was determined 245 samples with Cochran's formula:

$$n = \frac{Nt^2 S^2}{Nd^2 + t^2 s^2} = \frac{5600 \times (1/96)^2 \times (0/817)^2}{5600 \times (0/1)^2 + (1/96)^2 \times (0/817)^2} = 245$$

In the above formula, n is sample size, s standard deviation of the desired trait in the population, N is population size and d is desirable probable accuracy. To determine standard deviation for the desired trait in the studied population and also determine desirable potential accuracy with pretest method, 30 samples of the studied statistical population were selected randomly and the questionnaire was completed. To determine the number of sample in two utilization systems, Proportional allocation method was used, on which basis, the number of sample is equal to 207 and 38 in smallholding and production cooperative utilization systems. Sampling method was based on two-staged cluster method and in the first stage, some villages were selected in the studied region (first cluster) and then the desired sample was randomly selected among farmers of the said villages (second cluster).

RESULTS AND DISCUSSION

Results of calculating productivity indices of CPD, BPD, and NBPD for crops of two studied utilization systems including wheat, barley, alfalfa, cotton, fodder beet, millet, and sorghum are presented in Tables 1 and 2. Based on information of Table 1, the highest and lowest water consumption per hectare among the crops of smallholding utilization system related to alfalfa and barley, which was equal to 12042 and 6566 m^3/hectare. Based on CPD index, beet crop has the highest production rate for each m^3 of water. On the contrary, cotton has had the lowest production for consumed water, which has significant difference from each other and other crops.

Maximum and minimum value of BPD index which shows gross profit for the consumed water per hectare related to barley and cotton, respectively. Based on results of calculating

Table 1: CPD, BPD, and NBPD Indicators for products of smallholding systems

item	crops					
	wheat	barley	cotton	alfalfa	fodder beet	millet
Water consumption (Cubic meters per hectare)	7025	6566	10700	12042	11851	8080
Yield (Kg per hectare)	2770	2790	1530	5357	17464	2322
Gross income per hectare (IRR)	7966850	6685440	10074070	11789440	11945650	12378570
Cost per hectare (IRR)	6492320	5829960	4693620	4900050	10531020	8878700
Net income per hectare (IRR)	1474530	855470	5380460	6889380	1414640	3499870
CPD (Kg per m^3) *	0.57 bc	0.86 bb	0.15 d	0.51 cc	1.54 a	0.31 ddc
BPD (IRR per m^3)	1660 aabb	2460 aa	1020 b	1140 bb	1030 bb	1630 abb
NBPD (IRR per m^3)	227 abb	573 aa	556 aa	564 aa	128 b	145 bb

*Means with the same letter(s) in each row have not significantly different based on Duncan's test (p<0.05)

NBPD index, barley and beet with 573 and 128 Rials/ m^3 of water had the maximum and minimum net benefit per drop.

Considering the calculated value of water productivity indices, smallholding-farming priorities can be determined. In the agricultural year studied in smallholding utilization system, the highest cultivated area has been allocated to crops such as wheat, barley, cotton, alfalfa, beet and millet. Considering value of the said indices, it can be said that in case goal of farmers is to maximize quantity of the produced crop for each m^3 of water, cultivation priority is placed on beet, barley, wheat, alfalfa, millet and cotton. To obtain maximum profit, smallholding cultivation priority includes barley, alfalfa, cotton, wheat, millet, and beet, respectively. Although beet is in the first priority of cultivation based on CPD index, it is in the last priority of cultivation based on NBPD productivity index. This

Table 2: CPD, BPD, and NBPD Indicators for products of rural production cooperatives

item	crops				
	wheat	barley	cotton	alfalfa	Sorghum
Water consumption (Cubic meters per hectare)	8206	6567	12451	12061	13748
Yield (Kg per hectare)	3120	4080	2388	5680	7866
Gross income per hectare (IRR)	9126190	6049480	20865940	13832500	20020000
Cost per hectare (IRR)	6347060	5520980	7242300	5778270	11906500
Net income per hectare (IRR)	2779120	528500	13623640	8054220	8113500
CPD (Kg per m^3)*	0.422 c	0.673 aa	0.212 d	0.482 bcc	0.604 abb
BPD (IRR per m^3)	1260 abb	1770 aabb	1840 aa	1180 b	1530 aabb
NBPD (IRR per m^3)	404 b	900 abb	1200 aa	697 bb	612 bb

*Means with the same letter(s) in each row have not significantly different based on Duncan's test (p<0.05)

Table 3: Comparison of CPD indicator among joint products of smallholding systems and rural production cooperatives

Crop	Farming system		t-value	p-value
	Smallholding System	Rural production cooperative		
wheat	0.574	0.422	0.626	0.534
barley	0.864	0.673	1.233	0.221
alfalfa	0.512	0.482	0.565	0.575
cotton	0.154	0.212	-2.98*	0.004

*p<0.05

result is in line with studies by Soltani *et al.* (2007) and Sanee and Hassan Poor (2009). It is not surprising that the information used in each index is different from another index. However, considering conditions of the region which have experienced consecutive droughts in the past years and face crisis of water shortage and drop of aquifer level, it seems that the mentioned cultivation pattern is more suitable based on NBPD index which considers costs and incomes resulting from consumption of each m3 of water in offering of the crops of the region.

Results of calculating CPD, BPD and NBPD about major crops in rural production cooperative system are given in Table 2. Based on information of the above Table, the maximum consumable water per hectare related to cotton with 12451 m^3 and the minimum one relates to barley with 6567 m^3. The maximum value of CPD index relates to barley with 0.637 kg for each m^3 of water and the minimum value of index related to cotton with 0.212 kg for each m^3 of water. As information of the above Table shows, value of CPD index has significant difference among crops of this utilization system. The calculated value of the said index for wheat is close to result of studies by Soltani *et al.,* (2007) and Sanee and Hassan Poor (2009).

Results of calculating BPD productivity index show that the maximum and minimum gross profit for each m^3 of water in this system is equal to 1840 Rials and 1180 Rials, which relate to cotton and alfalfa, respectively. Value of this index for cotton has significant difference from other crops and this difference is not significant for other crops. The maximum NBPD (Net Benefit per Drop) in this system relates to cotton and is equal to 1200 Rials per m^3 of water. In addition, the maximum value of NBPD index relates to wheat and is 404 Rials per m^3 of water.

In the present cultivation pattern in production cooperative system in the studied year, the largest cultivated area relates to wheat, sorghum, barley, alfalfa and cotton, respectively. Information included in Table 2 shows that the present cultivation pattern of rural production cooperative system is not consistent with the proposed priorities obtained from the indices considering value of different indices of water productivity. In Tables 3 to 5, water productivity indices have been statistically compared with each other among the common crops between two utilization systems. As the results of table 3 shows, value of CPD index has no statistically significant difference between two utilization systems among crops of wheat, barley, and alfalfa and only value of this index has statistically significant difference in level of 5% for cotton.

Table 4: Comparison of BPD indicator among joint products of smallholding systems and rural production cooperatives

Crop	Utilization system		t-value	p-value
	Smallholding System	Rural production cooperative		
wheat	166.448	126.022	0.593	0.555
barley	246.413	177.106	1.618**	0.109
alfalfa	114.843	118.333	-0.259	0.797
cotton	101.590	184.068	-5.286*	0.000

*p<0.05, **p<0.10

Table 5: Comparison of NBPD indicator among joint products of smallholding systems and rural production cooperatives

Crop	Utilization system		t-value	p-value
	Smallholding System	Rural production cooperative		
wheat	22.752	40.403	-1.128	0.264
barley	57.368	90.010	-1.397	0.169
alfalfa	56.476	69.776	-0.936	0.355
cotton	55.686	120.408	-4.601*	0.000

*p<0.05

Tables 4 and 5 show BPD and NBPD indices in two smallholding and rural production cooperative utilization systems in the studied zone. The said indices are different in crops of two utilization systemsto be studied. However, difference of the said indices is statistically significant for cotton. It means that although gathering of farmers in rural production cooperative could increase water economic productivity, the said effect was lower for productivity of wheat, barley and alfalfa and its special effect is found in cotton.

It is clear that the obtained results will be more accurate and documented by increasing statistics and information and conducting similar studies in some consecutive periods. However, results of the present research can clarify conditions in utilization systemsof Khosef plain in South Khorasan Province, therefore, as Ghasemian and Eshraghi (2012) mention, finding the best opportunity to create higher value added can be a step for more effective growth of farming and economy of the region and the country considering shortage and high value of water input in the country.

CONCLUSION

To compare water productivity in production of crops in peasant and production cooperative utilization systems, CPD, BPD, and NBPD indices were calculated. Results showed that value of the said productivity indices in rural production system was higher than that of small holding system. On the other hand, cultivation priorities in two said utilization systems are not consistent with prioritization of productivity indices. Considering the said fact, combination of cultivation can be changed to improve condition of farmers in two utilization systems on the one hand and save water on the other hand. In this case, production efficiency of crops can be improved in the region by deleting cultivations with high water consumption and low yield and replacing them with cultivations with lower water consumption, higher yield and higher economic profit. Considering the problems which drought has created for the farmers in recent years, it is recommended to avoid more water-more yield option in irrigation management and planning of the studied region and consider less water –more yield option and perform cultivation pattern based on maximum economic productivity of plants' water consumption i.e. NBPD to increase effectiveness of using water resources. On this basis, gathering of smallholder's farmers in production cooperatives is recommended as one of the optimal utilization strategies for water resources and reduction of drought effects and water crisis.

REFERENCES

1-Cai X., Rosegrant M., & W. Ringler C. (2003). Physical and economic efficiency of water use in the river basin: Implications for efficient water management. Water Resour Research. 39(1): 1013-1025.

2-Ehsani, M., & Khaledi, H. (2003). Agricultural water productivity. Iran Irrigation and Drainage National Committee. Tehran.

3-Ghasemian, S., & Eshraghi F.(2012). Studying economic productivity of water consumption in Golestan Province. Agricultural Water Research Journal. 26(3), 317-322.

4-Henry, E.I., Henry, F.M., Andrew, K.P.R., & A.S.Baanda. (2006). Crop water productivity of an irrigated maize crop in Mkoji sub-catchment of the Great Ruaha River Basin, Tanzania. Agricultural Water Management, 85(2), p. 141-150.

5-Hussain, R.Z., & Young R.A. (1985). Estimates of the Economic Value Productivity of Irrigation Water in Pakistan from Farm Surveys. Journal of The American Water Resources Association. 21(6), 1021–1027.

6-Khaki, G.H. (2003). Productivity Management (its analysis in organization). Islamic Azad University Scientific Publication Center, Tehran.

7-Kijne, J.W., Tuong, T.P., Bennett, J. Bouman, B., & Oweis, T. (2002). Ensuring food security via improvement in crop water productivity. Available online at: http://citeseerx.ist.psu.edu/viewdoc/. Accessed 25 January 2012.

8-Liu, J., Zehnder, A. J. B., & Yang, H. (2008). Drops for crops: modelling crop water productivity on a global scale. Global NEST Journal, 10(3), p. 295-300.

9-Poor Sani, A., Akbari Toodehi, D., & Arya Vand, H. (2008). Analyzing Agricultural water productivity indices in a rural production cooperative. The second conference on irrigation and drainage systems management. Shahid Chamran University of Ahwaz.

10-Randhir, S., & murthy, K. (1999). Productivity variation and use in farm of madratkam takfed area of changal patuu district tamilnadu.Indian Joumal of Agriculture Economics. 45(1), 56-60.

11-Rohani, S. (2005). Comparing water productivity in farmlands of member and non-member farmers of production cooperatives (case study: Hamedan Province). Journal of Agricultural Economy and Development. Pp: 53-84.

12- Sanee Dehkordi, KH., & Hassan Poor, A. (2009). Studying condition of water productivity based on CPD and BPD index in irrigation and drainage systems in Khoozestan and presenting suitable strategy for increasing them. 12th conference of National Iranian Irrigation and Drainage Committee.

13 -Singh, R., Van Dam, J.C., & Feddes, R.A. (2006). Water productivity analysis of irrigated crops in Sirsa District. Indian Agricutural Water Management, 82: 253-278.

14- Soltani, GH.R., Akbari., S.M.R., & Mohammadi, H. (2007). Studying agricultural water productivity in regions with drought (case study: Marvdasht-Kerman). Collection of papers of the sixth conference of Iranian Agricultural Economy. Mashhad. Iran.

15- South Khorasan Province Agricultural Jihad Organization.(2009). Statistical Yearbook. Statistics and Information Unit.

16 -Vali Zadeh, P. (2005). Studying productivity in economy of Iran. Department of Economic Investigation and Policies. Central Bank of Islamic Republic of Iran. Publication No. 24.

17- Zeid Ali, S., Khaledi, H., & Kholghi, M. (2008). Studying condition of water productivity in Moghan irrigation and drainage system. Collection of papers of the 11th conference of National Iranian Irrigation and Drainage Committee.

18- Zwart, S.J., & Bastiaanssen, W. G.M. (2004). Review of measured crop water productivity values for irrigated wheat, rice, cotton and maize. Agricultural Water Management, 69(2), p. 115-133