International Journal of Progressive Sciences and Technologies (IJPSAT)
ISSN: 2509-0119.

http://ijpsat.ijsht-journals.org
Vol. 27 No. 1 Junio 2021, pp.100-110

Performance Assessment of Irrigated Agricultural Systems: A Case Study of Mapakada Irrigation Division, Sri Lanka

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Abstract – There is an increasing concern about the performance of an irrigated agricultural system as pressure grows on water resources and problems increase regarding food security and sustainability of irrigated agricultural systems. Performance assessment of irrigated agricultural systems using comparative indicators, including irrigation efficiency, adequacy of water supply, and land and water productivity, helps determine issues and identify ways to improve system performance. The present study was carried to assess the performance of selected irrigated agricultural systems in Mapakada irrigation division using comparative performance indicators. In addition, the socio-economic status of the farming community in the selected irrigation systems was analysed. Results showed that the annual income of most of the farmers ranges from Rs.100,000 - Rs.200,000. The agriculture sector is less attractive to the young generation. Most of the farmers are above 50 years old and having landholding less than 3.5 acres. Paddy yield varies from 3.36 t/ha - 6.39 t/ha. Water shortage is a common issue in *Yala* season, which restricts cultivation, particularly in Demodara and Nagadeepa systems. Output per unit irrigation supply varies from \$0.04/m^3-\$0.23/m^3 in *Maha* and \$0.05/m^3-\$0.15/m^3 in *Yala* season. Sorabora system shows better performance, followed by Mapakada system. However, Demodara system shows the lowest performance in all aspects. Therefore, it is vital to implement appropriate measures to improve the performance of Demodara and Nagadeepa irrigated agricultural systems.

Keywords – Cropping intensity, Irrigated agriculture, Performance assessment,

I. INTRODUCTION

Rice cultivation is the primary form of agriculture in Sri Lanka. Nearly 1.8 million farm families are engaged in paddy cultivation island-wide. The extent of paddy cultivation during *Maha* and *Yala* seasons is about 560,000 ha and 310,000 ha, respectively [1]. Paddy is cultivated in both rainfed and irrigated systems in Sri Lanka. The rainfed area constitutes only about 23% of the national rice cultivated extent and accounts for only about 18% of the annual national rice production in Sri Lanka [2]. Further, there is high uncertainty in rainfed agriculture due to the frequent failure of monsoonal rainfall. It reveals the importance of irrigated agriculture in contributing to food security and poverty alleviation in Sri Lanka. According to recent studies, food demand is expected to increase in the future. Hence, sustainable production increases from irrigated agriculture should be achieved in order to meet the food demand of a rapidly growing population.

The improvement in the performance of an irrigation system mainly depends on how appropriately available resources are utilized in crop production. It is stated that proper management of land, water, and agricultural inputs along with efficient operation

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and maintenance of irrigation systems are prerequisites for achieving optimum yield from the agricultural lands [3]. Further, implementation of proper irrigation scheduling methods and improving the system design and performance, and enhancing farmers' skills to control and manage the irrigation system more efficiently during its operation are imperative to improve the irrigation system's performance. The irrigation system's performance is expressed by its measured levels of achievement in terms of one or more parameters which are selected as indicators of the system's goals [4]. The exploration and utilization of water resources for irrigation require that there are periodic evaluations of its utility and efficiency of use. Performance assessment of irrigation systems using suitable comparative performance indicators helps identify the shortcomings and find solutions for increasing the systems' productivity [5], [6]. This assessment provides different stakeholders such as managers, farmers, and policymakers to understand better how a system operates. Further, irrigation performance assessment is considered an important management tool to implement, monitor, and evaluate water delivery services in the command area. It also enables the management process to function effectively and efficiently. There is a clear relationship between performance assessment and organizational excellence [7].

Mapakada irrigation division is one of the major irrigation divisions in Mahiyangana in Badulla district. This division comprises seven irrigation systems. Frequent crop failure, abandoning cultivation, and reduced crop yields are the common issues in some systems, mainly due to climate variability and inappropriate management of available resources. It affects food production and incomes of the farming community and has a significant impact on public investment on rural development and often recurrent public expenditures for the agricultural sector. In the above context, the present study was aimed to assess the performance of selected irrigated agricultural systems in Mapakada irrigation division using selected comparative indicators and to analyse the socio-economic status of the farming communities in the selected irrigation systems.

II. Materials and Methods

2.1 Study area

This study was carried out in Mapakada irrigation division. It is the most prominent farming area in Mahiyangana in Badulla district. This division has seven irrigation systems. Among these irrigation systems, four irrigation systems namely; Mapakada, Demodara, Sorabora and Nagadeepa systems, were selected in this study based on the formal and informal discussions with farmers and irrigation officials. Figure1 shows the location of Mapakada irrigation division and selected irrigation systems.

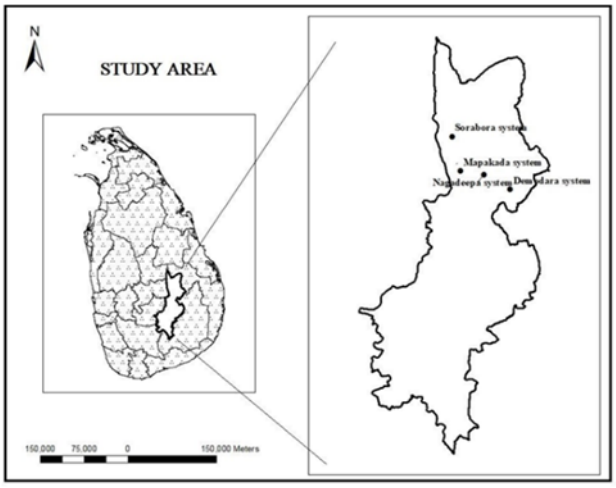

Figure1: Location of the Mapakada irrigation division and selected irrigation systems

2.2 Data collection

Primary data were collected via field observation and questionnaire survey. Secondary data such as reservoir operational data, cultivation data, rainfall data, effective rainfall data, monthly average evapotranspiration data, percolation and seepage data, and water diversion data were collected from the irrigation department. Formal and informal discussions with farmers and water managers were carried out to verify the collected data.

2.3 Assessment of socio-economic status

The socio-economic status of the farmers in the selected systems was assessed through questionnaires and informal discussions. A pre-test of prepared questionnaires was done before data collection. The questionnaires were distributed among the randomly chosen farmers, considering the location of up, mid and downstream. The following simplified equation was used to calculate the sample size (Eq.1). This formula is based on a 95% confidential level and assumed the degree of variability P=0.5.

$$n = \frac{N}{1+N(e)^2} \qquad [8] \qquad \text{Eq. 1}$$

Where, *n* is the sample size, *N* is the population size and *e* is the designed level of precision or sampling error (e.g. ±5%).

2.4 Performance assessment of irrigation systems

The performance of selected irrigation systems in Mapakada irrigation division was assessed using the selected comparative indicators. Table1 shows the performance indicators and the formula used to estimate each indicator.

Table 1: Selected indicators for assessing the performance of irrigation systems

Performance indicators	Estimation
Agricultural production performance	
Crop yield per unit area	Total paddy yield/Total cultivated extent
Output per cropped area	Seasonal value of agricultural production/ irrigated crop area
Output per unit command area	Seasonal value of agricultural production/ Command area
Output per unit irrigation supply	Seasonal value of agricultural production/ Diverted irrigation supply
Output per unit water consumed	Seasonal value of agricultural production/ Volume of water consumed by ET
Water delivery performance	
Relative water supply	Total water supply (Rainfall + irrigation) /Crop water demand (Evapotranspiration + seepage and percolation losses)
Relative irrigation supply	Irrigation supply/Irrigation demand (Crop ET-effective rainfall)
Physical performance	
Cropping intensity	Annual cropped area/Cultivated area
Irrigation ratio	Irrigated land/Potential system command area

III. Results and Discussion

3.1 Socio-economic status of farmers in Mapakada irrigation division

3.1.1 Age distribution

In Mapakada system, the majority (74%) of the farmers are above 50 years old. Only 4% of farmers are below 40 years old. Nearly 22% of the farmers are within 40-50 years old (Table 2). Involvement of the young generation in farming activity is very low in this system. Although most of the farmers (60%) in the Demodara system are above 50 years old, 24% of the farmers are

below 40 years old. It reveals that more middle-aged farmers are involved in Demodara system than Mapakada system. Nearly 69% of the farmers in Sorabora system are above 50 years old and 31% are below 40 years old. It was observed that nearly 58% of the farmers in Nagadeepa are below 50 years old, of which 8% are below 30 years old. According to the informal discussion, although responsibility has been given to the young generation in some systems, old farmers have been the backbone and guiding the youngsters.

As observed in many Asian countries, the involvement of the young labour force in agriculture shows a declining trend. Many factors make the agricultural sector not attractive to the young and educated workforce. Among them, increasing scarcity of agricultural land, uncertainty in income, and more promising and higher revenue from non-agricultural sectors are important. Further, most of them consider that working in non-agricultural sectors is more prestigious than working in the agricultural sector.

3.1.2 Family size distribution

The larger the number of household members in a farming family, the greater the chances for the young workforce to work on the farm. In this irrigation division, most young family members are engaged in both agricultural and non-agricultural sectors. In some irrigation systems, students are also involved in farming activities. The family size of 62% of the farming families in Mapakada system ranges from 4-6 (Table 2). Nearly 36% of the farmers have the family size of less than 3. In Demodara system, about 60% of the farming community has less than 3 members and about 36% of them have 4-6 members. The family size of Sorabora system is mostly similar to Mapakada system. In Nagadeepa, nearly 54% of the farming community has a family size of 4-6, whereas 10% of the farming community has more than six family members.

3.1.3 Income distribution

The level of income per capita measures the wealth of the farming family. The annual income of most of the farming families ranges from Rs.100,000 - 200,000 in all systems, except Demodara (Table 2). Nearly 44% of the farmers in Mapakada system receive income of more than Rs.200,000. The corresponding figures for Demodara, Sorabora, and Nagadeepa are 23%, 61%, and 24%, respectively. In Sorabora system, about 27% of farmers have an income of more than Rs. 400, 000 per year. Overall, the income level of farmers in the Sorabora system is higher than other systems in the Mapakada irrigation division. The mean income of farmers in the Sorabora system is Rs. 278,458, which differs significantly from other systems at 5% significance level. The mean income of Mapakada, Demodara, and Nagadeepa systems is Rs.189,848, Rs. 134,761, and Rs.148,974, respectively. Income level has a significant influence on the livelihoods of the farming community. Further, the higher the income from farming, the greater the chances for young members to be engaged in agriculture.

3.1.4 Land extent and ownership

Extent and ownership of the land influence farmers to decide agriculture as part-time employment or full-time employment. Some farmers whose land size is small prefer to work as laborers in other farms for daily wages. In addition to their owned land, some farmers cultivate in others' land on profit sharing or rental basis. The majority of the farmers in all systems have their own land for farming activity. Nearly 80% of the farmers in Demodara and Sorabora have own land (Table 2). Only 58% of farmers in Mapakada and Nagadeepa have owned land and about 40% of them cultivate in both owned land and leased land. The corresponding figures for Demodara and Nagadeepa are 12% and 17%, respectively. Concerning the extent of cultivation, the land extent of all farmers in Mapakada and Nagadeepa is less than 3.5 acres. However, in Demodara system, about 24% of the farmers have land ranges from 3.5-7.5 acres, whereas about 4% of the farmers have land extent more than 7.5 acres.

Table 2: Socio-economic characteristics of the farmers in different irrigation systems

Particulars	Mapakada	Demodara	Sorabora	Nagadeepa
Age distribution	%	%	%	%
< 30 years	0	0	0	8
30-40 years	4	24	10	12
40-50 years	22	16	21	38
50-60	40	28	23	14
> 60 years old	34	32	46	28
Family size				
<3	36	60	38	36
4-6	62	36	60	54
>6	2	4	2	10
Annual income (Rs.)				
> 100,000	18	42	17	32
100,000 - 200,000	38	35	23	44
200,000 - 300,000	32	19	19	18
300,000 - 400,000	12	4	15	6
>Rs.400,000	0	0	27	0
Land extent				
< 3.5 ac	100	72	98	100
3.5-5.5 ac	0	12	2	0
5.5-7.5 ac	0	12	0	0
>7.5 ac	0	4	0	0
Land ownership				
Own	58	80	79	58
Lease	2	8	4	2
Both	40	12	17	40
Experience				
<15	2	44	2	22
16-30	22	16	23	36
31-45	50	28	48	20
46-60	18	12	23	22
> 61	8	0	4	0
Labour involvement				
Family labour	4	28	8	12
Hired labour	36	36	23	26
Both	60	36	69	62
Investment				
Own	20	48	23	48
With loan	80	52	77	52
Source of credit				
Bank	90	100	68	62
Money-lenders	10	0	32	38

3.1.5 Experience of farmers in agriculture

Beginners in farming are defined as those having 10 years or less experience [9]. Nearly 44% of the farmers in Demodara has less than 15 years of experience in farming. Almost 76% of the farmers have more than 30 years of farming experience and 8% of them have more than 60 years of experience in Mapakada system (Table 2). Nearly 75% of the farmers in Sorabora system have

more than 30 years of experience and the corresponding values for Demodara and Nagadeepa are 40%, and 42%, respectively. Comparatively, farmers in Demodara and Nagadeepa systems have less experience than the farmers in other systems.

3.1.6 Labour involvement in farming activities

More than 60% of farmers in all systems except Demodara use hired labourers in addition to family members to carry out their farming activities. In Mapakada system, 36% of the farmers use hired labourers only (Table 2). In Demodara system, about 36% of the farmers use both hired labourers and family members, while 28% of them use only family members in farming activities. Generally, hired labourers are used for certain farming activities such as land preparation, weeding, spraying, and harvesting. However, most of the routine works are done by family members.

3.1.7 Investment and source of credit for farming

In terms of investment, both Mapakada and Sorabora systems show high similarity. Nearly 80% of the farmers in both systems depend on loans for cultivation (Table 2). However, only 52% of the farmers in Demodara and Nagadeepa get the loan for cultivation. Most of the farmers get loans from the Bank. However, some farmers, particularly in Sorabora and Nagadeepa irrigation systems, depending on local money lenders. Getting a loan at a higher interest rate has significant impacts on their profits. Further, most farmers get inputs such as fertilizers and agrochemicals on a loan basis from local shops and pay money after harvesting.

3.2 Performance assessment of different irrigation systems

3.2.1 Agricultural production per unit cropped area

It indicates the efficiency of a system in terms of output per unit cropped area. In *Maha* season, paddy production ranges from 4.37 t/ha - 6.39 t/ha (Table 3). The highest production was recorded in Sorabora system except 2017/18 *Maha* season. Comparatively, production was low in Demodara system. Mapakada and Nagadeepa systems showed a similar crop yield. In *Yala* season, water shortage is the main issue experienced by the farmers. However, production was higher than *Maha* seasons in some systems.

Table 3: Agricultural production per unit cropped area in different irrigation systems

Maha	2012/13		2013/14		2014/15		2015/16		2016/17		2017/18	
	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha
Mapakada	5.38	910	6.05	1229	5.72	1225	6.39	1657	6.05	1604	6.05	1740
Demodara	4.37	739	4.37	878	5.38	1153	5.04	1308	0	0	4.71	1354
Sorabora	5.38	910	6.39	1297	6.39	1369	6.39	1657	6.39	1693	5.38	1547
Nagadeepa	4.71	794	5.38	981	6.39	1369	6.05	1570	0	0	5.38	1547
Yala	2013		2014		2015		2016		2017		2018	
	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha	t/ha	$/ha
Mapakada	5.38	910	6.05	1229	5.72	1225	5.38	1301	5.72	1553	5.88	1758
Demodara	4.71	389	0.00	0	5.38	1234	0.00	836	4.71	859	3.36	1123
Sorabora	6.05	1024	6.39	1297	6.05	1297	5.72	1547	6.39	1765	5.38	1608
Nagadeepa	5.04	546	0.00	0	5.04	1101	5.04	1107	4.71	1057	3.70	1121

The highest yield of 6.39 t/ha was recorded in 2014 and 2017 *Yala* seasons in Sorabora system. As observed in *Maha* season, Sorabora system showed highest production per unit cropped area in *Yala* season except 2018 season. Mapakada system recorded the second-highest yield. Demodara system showed lowest cropped yield in both *Maha* and *Yala* seasons. The lowest production of 3.36 t/ha was recorded in 2018 in Demodara system.

The output per unit cropped area ($/ha) varied from year to year due to fluctuations in the crop yield and unit price of the product. Mapakada and Sorabora systems showed higher production performance in all seasons except the 2014/15 *Maha* season. The average production in Sorabora system was $ 1412/ha in *Maha* season. The corresponding values for Mapakada, Nagadeepa and Demodara were $ 1394/ha, $ 1044/ha and $ 905/ha, respectively. Likewise, the average production in *Yala* season were $1423/ha, $1329/ha, $ 822/ha, and $ 740/ha in Sorabora, Mapakada, Nagadeepa and Demodara systems, respectively. Cultivation in 2016/17

Maha and in 2014 *Yala* seasons was abandoned in Demodara and Nagadeepa systems due to water shortage. Sorabora and Mapakada systems show more or less the same output in both *Maha* and *Yala* seasons. However, Demodara and Nagadeepa systems showed a substantial decline in output per unit cropped area in *Yala* season.

3.2.2 Agricultural production per unit command area

In most irrigation systems, cultivation extent is less than the actual command area, mainly due to water shortage. However, cultivation in *Maha* season is not restricted. However, unlike *Maha* season, farmers are advised to reduce the extent of cultivation due to water shortage in *Yala* season. As shown in Table 4, production per unit command area is higher in Mapakada and Sorabora systems. The highest production of $ 1765/ha was recorded in Sorabora system in 2017 *Yala,* whereas the lowest production of $ 389/ha was recorded in Demodara system in 2013 *Yala* season. Farmers cultivate the entire command area in both *Maha* and *Yala* seasons in Sorabora system. However, cultivation extent was restricted in 2016 *Yala* in other systems. Comparatively, restriction in the extent of cultivation in *Yala* season is very common in Demodara system.

Table 4: Agricultural production per unit command area

Maha	Production per unit command area ($/ha)					
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Mapakada	910	1229	1225	1657	1604	1740
Demodara	739	878	1153	1308	0	1354
Sorabora	910	1297	1369	1657	1693	1547
Nagadeepa	794	981	1369	1570	0	1547
Yala	2013	2014	2015	2016	2017	2018
Mapakada	910	1229	1225	867	1553	1758
Demodara	389	0	1124	743	821	998
Sorabora	1024	1297	1297	1547	1765	1608
Nagadeepa	546	0	1101	1094	1057	1121

3.2.3 Output per unit irrigation water

Output per unit irrigation supply varies over time in all systems (Table 5). Output per unit irrigation supply was higher in *Maha* season than *Yala* season. Comparatively, Sorabora system shows the better output per unit irrigation water supply in both seasons, while Demodara system shows the lowest output per unit irrigation water supply. The highest output of $ 0.23/m^3 was recorded in Sorabora system in 2016/17 *Maha,* while the lowest output of $ 0.04/ m^3 was recorded in Demodara system in 2012/13 *Maha* season. Further, the average output per unit irrigation water supply was the same in both *Maha* and *Yala* seasons in Nagadeepa and Demodara systems.

Table 5: Output per unit irrigation water in different irrigation systems

Maha	Output per unit irrigation supplied ($/$m^3$)					
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Mapakada	0.09	0.06	0.11	0.12	0.15	0.13
Demodara	0.04	0.05	0.08	0.07	NS	0.11
Sorabora	0.12	0.09	0.13	0.13	0.23	0.15
Nagadeepa	0.09	0.10	0.11	0.09	NS	0.11
Yala	2013	2014	2015	2016	2017	2018
Mapakada	0.05	0.07	0.08	0.06	0.09	0.10
Demodara	NS	NS	0.07	0.08	0.06	0.07
Sorabora	0.06	0.08	0.08	0.09	0.15	0.12
Nagadeepa	0.05	NS	0.09	0.09	0.08	0.20

NS- *Not supplied*

Irrigation water was not supplied in Demodara system during 2013 and 2014 *Yala* seasons. Nagadeepa was also not received irrigation water in 2016/17 *Maha* and 2013 *Yala* seasons. Reduction in overall output per unit irrigation supply in *Yala* season might be due to water stress. Further, irrigation water supply in addition to rainfall might have attributed to higher production in *Maha* season.

3.2.4 Output per unit water consumed

It is defined as output per actual crop water consumption (ETc). The highest output of \$0.41 per unit water consumed was observed in Mapakada system in 2017/18 *Maha* season. Demodara system showed the lowest output of \$ 0.17/ m^3 and \$ 0.09/ m^3 in 2012/13 *Maha* and 2013 *Yala* season, respectively. (Table 6). Mapakada and Sorabora systems showed more or less the same output per unit water consumed in both cultivation seasons. It was observed that output per unit water consumed in *Yala* season was lower than *Maha* season in all systems. Further, the lowest performance was observed in 2012/13 *Maha* and 2013 *Yala* seasons in all systems in the study area.

Table 6: Output per unit water consumed in *Maha* season

Maha	Output per unit water consumed (\$/m^3)					
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Mapakada	0.21	0.29	0.29	0.39	0.37	0.41
Demodara	0.17	0.21	0.27	0.31	NC	0.32
Sorabora	0.21	0.30	0.32	0.39	0.39	0.36
Nagadeepa	0.19	0.25	0.32	0.37	NC	0.36
Yala	2013	2014	2015	2016	2017	2018
Mapakada	0.14	0.19	0.19	0.22	0.24	0.27
Demodara	0.09	NC	0.27	0.20	0.16	0.19
Sorabora	0.16	0.20	0.20	0.23	0.27	0.24
Nagadeepa	0.11	NC	0.17	0.23	0.20	0.27

NC- Not cultivated

3.2.5 Relative water supply

Relative water supply relates water supply to demand and indicates the condition of water abundance or scarcity and how tightly supply and demand are matched. Relative water supply of more than 1 indicates excess water supply while less than 1 indicates water shortage. According to the Table 7, there was excess water supply in Mapakada system except 2016/17 and 2017/18 *Maha* seasons. However, water shortage was observed in Sorabora system in all seasons except 2014/15 and 2015/16 *Maha* seasons. Further, cultivation in 2016/17 *Maha* season was abandoned in both Demodara and Nagadeepa systems due to water scarcity.

Table 7: Relative water supply assessed in different irrigation systems

Maha	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Mapakada	1.05	1.11	1.35	1.06	0.86	0.84
Demodara	1.17	0.92	1.43	1.18	NC	0.88
Sorabora	0.95	0.85	1.32	1.04	0.72	0.71
Nagadeepa	0.90	0.68	1.33	1.16	NC	0.77
Yala	2013	2014	2015	2016	2017	2018
Mapakada	0.68	0.66	0.70	0.86	0.61	0.70
Demodara	0.07	NC	1.53	1.12	0.86	0.70
Sorabora	0.62	0.61	0.72	0.55	0.42	0.57
Nagadeepa	0.78	NC	0.49	0.80	0.75	0.75

NC-Not cultivated

Severe water deficit was observed in *Yala* season in all systems. However, excess water supply was observed in 2015 and 2016 *Yala* seasons in Demodara system. Mapakada and Sorabora systems are supported by both catchment flow and water diversion. However, these systems are also experienced water stress in *Yala* season. Comparatively, Demodara system shows the lowest water stress in both cultivation seasons.

3.2.6 Relative irrigation supply

Relative irrigation supply varies from season to season. Excess irrigation water supply was observed in Mapakada system except 2016/17 and 2017/18 *Maha* seasons. Demodara, Sorabora, and Nagadeepa systems showed excess water supply in 2014/15 and 2015/16 *Maha* seasons. Compared to other systems, Demodara system shows the highest relative irrigation supply, followed by Mapakada system in *Maha* season.

Table 8: Relative irrigation water supply assessed in different irrigation systems

Maha	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18
Mapakada	1.16	1.16	5.12	1.14	0.75	0.77
Demodara	1.32	0.90	4.28	1.35	NC	0.80
Sorabora	0.85	0.78	4.85	1.09	0.51	0.57
Nagadeepa	0.78	0.61	3.56	1.31	NC	0.69
Yala	2013	2014	2015	2016	2017	2018
Mapakada	0.65	0.63	0.63	0.86	0.59	0.65
Demodara	0.00	NC	1.65	1.12	0.84	0.68
Sorabora	0.60	0.57	0.66	0.55	0.39	0.51
Nagadeepa	0.76	NC	0.44	0.80	0.71	0.70

NC-Not cultivated

Relative irrigation water supply was less than 1 in *Yala* season in all systems except Demodara, which showed more than 1 in 2015 and 2016 *Yala* seasons. Irrigation water was not supplied for Demodara system in 2013 *Yala* due to water shortage. Overall, both relative water supply and relative irrigation supply were less than 1 in *Yala* season. Severe water shortage was observed in some seasons, particularly in 2013 and 2014.

3.2.7 Cropping intensity (CI)

Cropping intensity (CI) is the primary and essential criteria to measure irrigation service performance [5]. It varied from year to year and system to system over the past six years. Sorabora system is the only system that showed CI of 2 (200%) throughout the study period (Figure 2). Farmers in this system cultivate total command areas in both *Maha* and *Yala* seasons. Demodara and Nagadeepa systems showed the CI of less than 2, particularly in 2014 and 2017. It reveals that farmers in these two systems could not cultivate the entire command area in both seasons due to water shortage. However, farmers in both Mapakada and Sorabora systems were able to cultivate both seasons with the support of diverted water supply.

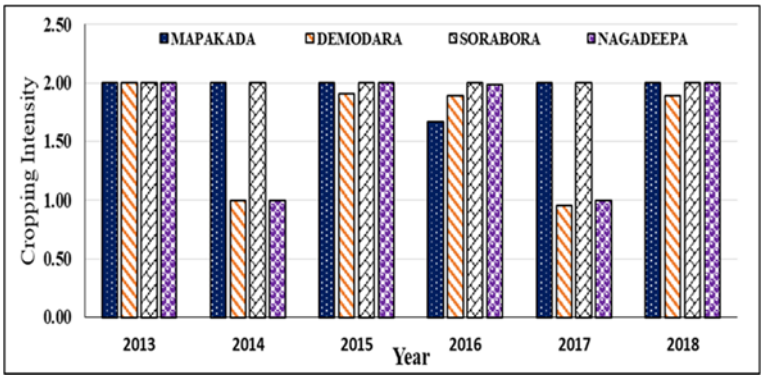

Figure 2: Cropping intensity of different irrigation systems in Mapakada division

3.2.8 Irrigation ratio

The irrigation ratio is one of the main indicators of farmer's willingness or unwillingness to engage in irrigation [10]. It also shows the ability of a system to supply water to an entire irrigable area. The irrigation ratio in *Maha* season was 1 in all systems in all years (Figure 3). It reveals that irrigation water was supplied to entire irrigable land in all systems. However, the amount of water supplied varied according to the availability of water. As discussed above, some systems receive excess water supply in some seasons, whereas water shortage was experienced in some systems in the same cultivation season.

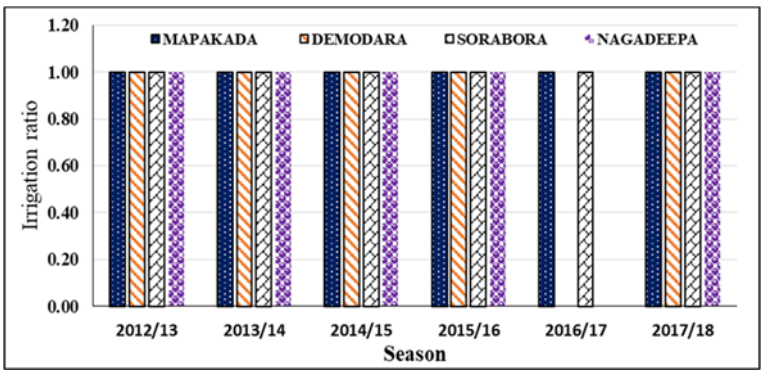

Figure 3: Irrigation ratio recorded in different irrigation systems in Maha season

However, there was uncertainty in irrigation water supply in *Yala* season. Water supply was restricted to some irrigable areas in all seasons except 2013 *Yala* in Demodara system (Figure 4).

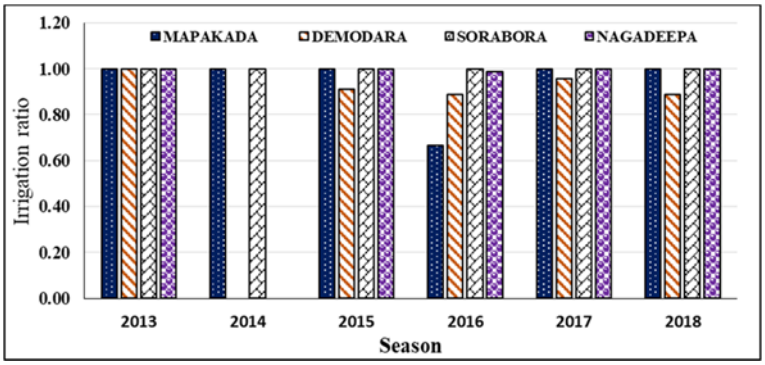

Figure 4: Irrigation ratio recorded in different irrigation systems in Yala season

Similar restriction in water supply to the irrigable area was also observed in Mapakada system in 2016 *Yala* season. Sorabora system supplied irrigation water to entire irrigable land in all seasons. Irrigation was totally restricted to Demodara and Nagadeepa systems in 2014 *Yala* season. Further, the irrigation ratio was less than 1 in Nagadeepa system in 2016 *Yala* season. Overall, except Demodara system, irrigation water supply was ensured to the entire irrigable land in *Maha* and *Yala* seasons. However, the volume of water supplied is less than demand, particularly in *Yala* season in this irrigation division.

IV. Conclusions

Overall performance of Sorabora and Mapakada irrigation systems is better than other systems. Water shortage in the dry season is the main issue in all systems. Comparatively, Demodara and Nagadeepa systems show low performance with regard to production per unit cropped area and output per unit water consumed. Hence, appropriate measures should be taken to improve the performance of these irrigation systems in Mapakada irrigation division.

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