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Impact of Irrigation and Rainfall on Wet Rice Cultivation in Mizoram

J.V. Nunchunga*

Abstract

This paper analyzes the impact of irrigation and rainfall on the productivity of WRC as well as overall Paddy production. It has been established that irrigation facility is of no use for increasing the productivity of WRC and paddy production in the state. Rainfall reduces the total production and Productivity of Paddy (WRC + Jhum) during the study period.

Key words: WRC, Paddy, Rainfall, Irrigation, Production and Productivity.

Introduction

Agriculture plays a very important role in the economy of Mizoram and has remarkable contribution to the state Gross Domestic Products. More than 70% of the State population depends on land based activities for their livelihood. Agriculture is one of the sustainable land based activities/industries for development of the State economy due to its favourable agro-climatic condition, hilly terrain nature of the landscape and abundant rainfall during monsoon season.

The agriculture & allied activities contributed 18.75% (2015-16) to the GSDP. With more than half of the population deriving the greater part of their income from agriculture, faster growth in agriculture is necessary to provide boost to their income. Rising incomes in agriculture will also be an impetus to non-agricultural income in rural areas thus helping redress the rural-urban imbalance.

The contribution of agriculture and allied sector to the economy in terms of Gross State Value added by economic activity at constant prices (2011-2012) was 20.12%, 18.43% 18.51% and 17.46% respectively in 2011-12, 2012-13, 2013-14 and 2014-15.

* Dr. J.V. Nunchunga is Associate Professor, Dept of Economics, Govt. J. Thankima College, Aizawl.

Table 1 [Sectoral Share in percentage (Base year 2011-2012)]

Year	Agriculture & Allied Sector		Industry Sector		Service Sector	
	Current Price	Constant (2011-12)	Current Price	Constant (2011-12)	Current Price	Constant (2011-12)
2011-2012	20.12	20.12	20.46	20.46	59.43	59.43
2012-2013	18.95	18.43	18.91	18.83	62.14	62.74
2013-2014	18.74	18.51	23.24	20.47	58.02	57.03
2014-2015 (P)	19.15	17.46	24.59	20.38	56.26	58.04
2015-2016 (Pr)	18.75	16.39	25.6	19.88	55.64	57.43
2016-2017 (Pr)	18.43	16.12	26.42	19.53	55.15	57.2

Source: Economic Survey Mizoram 2016-17

Objectives of the Analysis

The objectives of this study are

1) To analyse the impact of rainfall and irrigation facilities on the productivity of WRC

2) To describe the impact of WRC and rainfall on the state overall Paddy production and productivity.

Methodology and Tools of Analysis

Out of the two analytic approaches - Predictive and Descriptive analytics, this study is the Predictive analytics in nature as the analysis is based on past record of the production. Statistical tools like ANOVA, Standard error, R^2, Correlation coefficient etc are employed through SPSS software.

Nature of Data

All data are collected from various departments like Economics & Statistics, Agriculture and other publications of state government. As the data are secondary in nature, the accuracy and reliability shall rest on the concerned departments.

WRC Status in the State

Due to hilly terrain, the available WRC areas of the state are very limited and scattered. The studies using Remote Sensing and Geographical Information System (GIS) techniques confirmed that there are 74,644 hectares of area having a slope of 0-25% potential for WRC area. The net cultivated area (WRC areas) is only 17,302 hectares and the remaining areas of 57,342 hectares needs to be developed to make the land suited for crop production to meet the growing food requirement of the State.

Table 2 (District-wise availability of WRC Potential & Utilization Status 2015-16)

Sl. No.	Name of District	WRC Potential Area (in Ha.)	Area under Cultivation	% utilization of WRC Potential	Area need to be developed
1	Aizawl	4,140	875	21.14	3,265
2	Lunglei	12,797	1,202	39	11,595
3	Saiha	4,284	504	76	3,780
4	Champhai	8,697	4,554	52.36	4,143
5	Kolasib	9,429	4,335	98	5,094
6	Serchhip	3,710	2,308	62.21	1,402
7	Lawngtlai	11,405	2,556	22.41	8,849
8	Mamit	20,182	968	4.8	19,214
	Grand Total	74,644	17,302	23.18	57,342

Source: Economic Survey Mizoram 2016-17

To maintain standing water required for wet rice cultivation, irrigation had been started as early as when WRC was first introduced in the state. Irrigation was implemented as a scheme from the year 1974-75 when Minor Irrigation Scheme was included in the Annual Plan of Agriculture Department.

Under infrastructure development, expansion of Rice area was the priority sector during the 12th Plan period. The marginal increase in WRC Area has been recorded from 12,700 hectare at the beginning of 12th Plan to 17,302 hectares during 2015-16 which accounts for 36.24% increase. The productivity of Rice under WRC also increased significantly from 2.00 MT/Ha. at the beginning of 12th Five Year to 2.18 MT/Ha. during 2015-16.

Rainfall

Mizoram receives good monsoon Rains and the average monthly rainfall during 1986-2013 is given in the following table:

Table 3 [District-wise average monthly rainfall (in mm) for 1986 - 2013]

Month	Aizawl	Champhai	Kolasib	Mamit	Serchhip	Lunglei	Lawngtlai	Saiha	Mizoram
Jan	11	10.94	9	9.8	5.9	6.2	10.3	11.7	9.36
Feb	27.6	20.17	36.6	14.6	20.9	15.3	18.1	24.1	22.17
Mar	99.6	71.65	101.4	86.6	81.6	61.6	47.2	46.7	74.54
Apr	191.4	127.05	215.5	236.8	116.1	110.6	116.7	103.8	152.24

Month	Aizawl	Champhai	Kolasib	Mamit	Serchhip	Lunglei	Lawngtlai	Saiha	Mizoram
May	373.7	250.39	342.1	451	330.1	309.4	327.6	371.4	344.46
Jun	449.5	355.5	431.1	432.2	426.3	462.5	474.3	457.1	436.06
Jul	519.6	374.88	463.7	397.2	405.6	466	482.8	434.4	443.02
Aug	557.6	392.01	514.7	529.1	395	462.6	389.7	450.1	461.35
Sep	529.5	400.53	444.9	480.3	330.1	417.8	350.7	398.1	418.99
Oct	295.5	234.03	218.4	309.6	184.8	225.6	206.8	230.3	238.13
Nov	67.3	62.24	36.7	26	62.8	46.7	53	71.4	53.27
Dec	29.3	19.98	19.9	9.2	21.6	12.2	5.8	12.2	16.27
Total	3152	2319.37	2834	2982	2380.8	2596.5	2483	2611	2669.9

Source: Source: Economic Survey Mizoram 2016-17

Even with this much of annual rainfall, irrigation is still indispensable due to uneven seasonal distribution of rainfall. 74.82%, 3.79% and 21.40% of the rain falls during June – October (Kharif), November – February (Rabi) and March – May (summer) respectively.

Effect of Rainfall and Irrigation on the Productivty of Wet Rice Cultivation

The district wise rainfall, Net irrigated area and Minor irrigation completed from 2005-06 to 2015-16 are taken as predictor for the WRC productivity, so that there is 88 observations. As there is no adequate district wise Net irrigated area data for the study period, using regression estimator, Culturable Command area is used as Net irrigated area. The correlation coefficient matrix is obtained using SPSS software. The correlation between Rainfall and WRC Productivity is -0.507 which is statistically significant at 5%. The rainfall reduces the productivity of WRC up to the extent of 25.70%.

Table 4 (Effect of rainfall and Irrigation on Productivity of WRC)

		Rainfall (mm)	WRC Productivity	Net irrigated area	MI Completed
Rainfall (mm)	Pearson Correlation	1	-.507**	-0.067	-0.05
	Sig. (2-tailed)		0	0.535	0.644
	N	88	88	88	88
WRC Productivity	Pearson Correlation	-.507**	1	.215*	0.198
	Sig. (2-tailed)	0		0.044	0.064
	N	88	88	88	88

		Rainfall (mm)	WRC Productivity	Net irrigated area	MI Completed
Net irrigated area	Pearson Correlation	-0.067	.215*	1	.999**
	Sig. (2-tailed)	0.535	0.044		0
	N	88	88	88	88
MI Completed	Pearson Correlation	-0.05	0.198	.999**	1
	Sig. (2-tailed)	0.644	0.064	0	
	N	88	88	88	88
** Correlation is significant at the 0.01 level (2-tailed).					
* Correlation is significant at the 0.05 level (2-tailed)					

Regarding the effect of irrigation facility on the productivity of WRC Cultivation, the relationship between Net irrigated area and Productivity of WRC are related up to the extent of (0.215^2 =) 4.62% only. This implies that Irrigation facility has no significant impact for increasing productivity of WRC.

Table 5 (Model Summary of WRC for Mizoram)

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate
1	0.569	0.324	0.3	70.61485
Predictors: (Constant), Rainfall, MI Completed, Net irrigated area				

The predictors - Rainfall, MI Completed and Net irrigated area explained 32.4% of the total change in the productivity of WRC.

Table 6 (Coefficients table of WRC for Mizoram)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	472.342	66.097		7.146	0
	Net irrigated area	0.076	0.036	4.2	2.137	0.035
	MI Completed	-3.241	1.584	-4.018	-2.047	0.044
	Rainfall mm	-0.101	0.023	-0.427	-4.448	0
Dependent Variable: WRC Productivity						

Linear regression model for the above data is

$$^{W}P = 472.342 + 0.076\,C - 3.241\,M - 0.101Ra,\ R^2 = 32.4\%$$
$$\textit{(60.092)} \quad \textit{(0.036)} \quad \textit{(1.584)} \quad \textit{(0.023)}$$

where ^{W}P - Productivity of WRC for Mizoram (Kg/Ha), C –Net irrigated area (Ha), M – Minor Irrigation Completed (nos) and Ra – Rainfall(mm). Figure in parenthesis indicates Standard error of the coefficients. An increase in Net irrigated area /Culturable Command area (Ha) enhances the productivity of WRC by 0.076 Kg/Ha while Minor Irrigation completed and rainfall reduced the productivity by 3.241Kg/Ha and 0.101Kg/Ha respectively

Effect Of Rainfall And Irrigation On Production Of Paddy (District Wise Analysis)

The effect of rainfall and irrigation facility (in terms of net irrigated area) on the state's overall Paddy production (WRC + Jhum) between 2008-09 to 2016-17 is summarized in table 7 in the form of model summary.

Table 7 (R^2 table for rainfall and irrigation on the district wise paddy production)

Sl. No	District	R	R^2	Adjusted R Square	Std. Error of the Estimate
1	Mamit	.657[a]	0.432	0.204	3681.02969
2	Saiha	.106[a]	0.011	-0.384	2856.62787
3	Serchhip	.230[a]	0.053	-0.326	5012.5975
4	Kolasib	.839[a]	0.704	0.585	2172.49592
5	Champhai	.203[a]	0.041	-0.342	6501.55558
6	Lawngtlai	.355[a]	0.126	-0.224	3424.65261
7	Lunglei	.256[a]	0.065	-0.308	5701.77405
8	Aizawl	.150[a]	0.023	-0.368	5047.05548
Predictors: (Constant), Rainfall, Irrigation					

The Predictors are rainfall and net irrigated area while district paddy production is taken as independent variable. The value of R^2 for 5 districts viz Saiha, Serchhip, Champhai, Lawngtlai, Lunglei and Aizawl are extremely low which implies that the predictors have negligible impact on independent variable. To be more specific, all the adjusted R^2 are negative. However, the coefficient of determination for Mamit and Kolasib are 43.5% and 70.4% respectively.

Table 8 (Coefficients table for Mamit district)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	18919.888	7134.823		2.652	0.045
1	Irrigation	-1.447	4.256	-0.115	-0.34	0.748
	Rainfall	-5.301	2.774	-0.644	-1.911	0.114
Dependent Variable: Paddy production (Mamit district)						

The regression model for the variables under study is

$$^{m}\text{Pro} = 18919.8 - 1.447\,\text{I} - 5.301\,\text{Ra}, \qquad R^2 = 43.2\%$$

$$(7134.8) \quad (4.256) \quad (2.774),$$

where ^{m}Pro – Paddy overall production of Mamit district, I – Net irrigated area (Ha), Ra – Rainfall (in mm). Figure in parenthesis indicates Standard error of the coefficients. An increase of irrigated area (Ha) and rainfall (mm) reduces the paddy production by 1.447Kg/ Ha and 5.301Kg/Ha respectively.

Table 9 (Coefficients table for Kolasib district)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12874.318	4839.779		2.66	0.045
	Irrigation	1.889	1.116	0.419	1.692	0.151
	Rainfall	-4.349	1.329	-0.811	-3.271	0.022
Dependent Variable: Paddy production (Kolasib district)						

$$^{K}\text{Yield} = 12874.318 + 1.889\,\text{I} - 4.349\,\text{Ra}, \qquad R^2 = 70.4\%$$

(4839.779) (1.116) (1.329), where ^{K}Yield – Paddy overall production of Kolasib district, I – Net irrigated area (Ha), Ra – Rainfall (in mm). Figure in parenthesis indicates Standard error of the coefficients. An increase of irrigated area (Ha) enhances the paddy production by 1.116Kg/Ha while rainfall (mm) reduces the paddy production by 4.349 Kg/ Ha.

The Whole State as a Unit of Observation

1) On state's overall Paddy production: The state's overall Paddy production and its productivity, net irrigated area and rainfall from 1998-99 to 2015-16 was presented in annexure 5 and the relevant correlation coefficients in table 10.

Table 10 (Correlation Coefficients for rainfall and irrigation on the overall paddy production- Temporal data)

		Irrigation	Rainfall	Production	Productivity
Irrigation	Pearson Correlation	1	-.469*	0.028	0.028
	Sig. (2-tailed)		0.05	0.911	0.911
	N	18	18	18	18
Rainfall	Pearson Correlation	-.469*	1	-0.068	-0.111
	Sig. (2-tailed)	0.05		0.789	0.661
	N	18	18	18	18
Production	Pearson Correlation	0.028	-0.068	1	.562*
	Sig. (2-tailed)	0.911	0.789		0.015
	N	18	18	18	18
Productivity	Pearson Correlation	0.028	-0.111	.562*	1
	Sig. (2-tailed)	0.911	0.661	0.015	
	N	18	18	18	18
*Correlation is significant at the 0.05 level (2-tailed)					

Irrigation does not increase the state's overall paddy production (0.028) as well as its productivity (0.028). Meanwhile, there is chance that an increase in rainfall decreases the production (-0.068) and productivity (-0.111) of paddy. The overall impact of irrigation and rainfall on Production (R^2) is 5% (adjusted -12.8%) which is insignificant.

Table 11 (ANOVA table for paddy Production)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	7.07E+07	2	3.54E+07	0.035	.966[a]
	Residual	1.52E+10	15	1.01E+09		
	Total	1.53E+10	17			
Predictors: (Constant), Rain, Irrigation						
Dependent Variable: Production						

2) On state's overall Paddy productivity: The effect of irrigation and rainfall on the productivity of Paddy for the 18 years is insignificant as their correlation coefficients are 0.028 and - 0.111 respectively with $R^2 = 3.1\%$. That is to say, adequate water is not helpful for increasing the productivity of paddy in Mizoram. The coefficients table is depicted in table 12

Table 12 (ANOVA table for paddy Productivity)

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	59041.958	2	29520.979	0.243	.787[a]
	Residual	1823119.153	15	121541.277		
	Total	1882161.111	17			
Predictors: (Constant), Rain, Irrigation						
Dependent Variable: Productivity						

Conclusion

1) Irrigation facility has no significant impact in increasing the productivity of WRC

2) In regard to district wise analysis, an increase in Rainfall and Net irrigated area have no significant impact on the total paddy production for Saiha, Serchip, Aizawl, Champhai and Lunglei districts.

3) However, in Mamit district, an increase of irrigated area (Ha) enhances the paddy production by 1.116Kg/Ha while rainfall (mm) reduces the paddy production by 4.349 Kg/ Ha. In Kolasib district, an increase of irrigated area (Ha) and rainfall (mm) reduces the paddy production by 1.447Kg/ Ha and 5.301Kg/Ha respectively

4) Taking the state as a whole, Irrigation does not increase the state's overall paddy production (WRC + Jhum) as well as its productivity.

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Annexure 1 (District wise rainfall from 2005-06 to 2015-16)

Rainfall (mm)

Year	Aizawl	Champhai	Kolasib	Lawngtlai	Lunglei	Mamit	Saiha	Serchhip
2005-06	2436	1640	2590	2461	1863	1968	2256	1370
2006-07	2717	1806	3721	2136	2298	2965	1888	1745
2007-08	3375	1550	2820	2832	3314	3130	3730	2990
2008-09	2330	1799	2108	1872	1307	1225	2590	2054
2009-10	2047	1571	2764	2471	1378	2651	1752	758
2010-11	3013	2220	3837	2041	2861	2781	2810	2494
2011-12	2577	1736	2978	2254	2368	2344	2714	1954
2012-13	2939	1940	2883	901	2685	2255	1596	2163
2013-14	2689	2015	2892	1919	2584	2510	3572	1445
2014-15	2284	1548	2003	1541	1882	1817	1887	1445
2015-16	2732	1865	1998	1673	2287	2128	2231	1792

Annexure 2 (Area, production and productivity of WRC for Aizawl, Champhai and Kolasib district from 2005-06 to 2015-16)

Year	Aizawl			Champhai			Kolasib		
	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)
2005-06	1,358	3,841	283	4,809	10,685	222	2,828	8,010	283
2006-07	440	384	87	2374	1319	56	3515	1042	30
2007-08	440	384	87	2374	1319	56	3515	1042	30
2008-09	300	381	127	3562	9421	264	3547	7300	206
2009-10	308	695	226	3345	10070	301	2495	5488	220
2010-11	399	573	144	3750	8148	217	3592	5850	163
2011-12	621	1281	206	3775	7639	202	3657	6877	188
2012-13	656	1855	283	3993	8135	204	4141	7596	183
2013-14	740	1665	225	4384	9338	213	4244	7983	188
2014-15	835	2010	241	4479	8915	199	4333	8987	207
2015-16	875	2100	240	4554	10018	220	4335	9050	209

Annexure 3 (Area, production and productivity of WRC for Lawngtlai, Lunglei and Mamit district from 2005-06 to 2015-16)

Year	Lawngtlai			Lunglei			Mamit		
	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)
2005-06	992	2,157	217	793	2,890	364	1,365	4,248	311
2006-07	712	356	50	651	391	60	173	146	84
2007-08	712	356	50	651	391	60	173	146	84
2008-09	1025	1071	104	454	745	164	510	669	131
2009-10	1200	1764	147	507	813	160	589	1603	272
2010-11	1260	1282	102	472	533	113	635	980	154
2011-12	1639	2957	180	607	607	100	1470	755	51
2012-13	1795	3388	189	987	2372	240	798	1731	217
2013-14	2257	4351	193	4335	6156	142	3138	4059	129
2014-15	2478	6216	251	1152	2719	236	968	2426	251
2015-16	2556	5735	224	1202	2422	201	968	2052	212

Annexure 4 (Area, production and productivity of WRC for Saiha, Serchhip district and all Mizoram from 2005-06 to 2015-16)

Year	Saiha			Serchhip			TOTAL (MIZORAM)		
	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)	Area (Ha)	Production (MT)	Productivity (MT/Ha)
2005-06	555	2,259	407	1,450	3,850	266	14,150	37,940	268.13
2006-07	376	43	11	1353	652	48	9,594	4,333	45.16
2007-08	376	43	11	1353	652	48	9,594	4,333	45.16
2008-09	315	191	61	1485	4650	313	11,198	24,428	218.15
2009-10	384	577	150	1535	1136	74	10,363	22,146	213.7
2010-11	426	544	128	1596	2793	175	12,130	20,703	170.68
2011-12	1483	461	31	923	1635	177	14,175	22,212	156.7
2012-13	509	1311	258	1757	4184	238	14,636	30,572	208.88
2013-14	1163	1703	146	4154	6930	167	24,415	42,185	172.78
2014-15	487	1043	214	2134	4780	224	16,866	37,096	219.95
2015-16	504	1096	217	2308	5273	228	17,302	32,473	187.68

Annexure 5

Mizoram overall data				
Year	Net Irrigated area (Ha)	Rainfall (mm)	Paddy Production (MT)	Productivity (Kg/MT)
1998-99	8.517	**2623.74**	38332	2279.77
1999-00	9.3	2571.7	30083	1884.55
2000-01	9.686	2883	103673	2000
2001-02	10.219	2535	105715	1892
2002-03	10.669	2648	109205	1914
2003-04	11.352	2546	114630	1936
2004-05	11.852	2751	107661	1886
2005-06	11.8	2094	107740	1908
2006-07	11.388	2338	42091	796
2007-08	9.446	3140	15688	288
2008-09	11.067	2175	68917	1326
2009-10	10.244	2052	66132	1401
2010-11	12.123	2889	67428	1657
2011-12	12.7	2379	75566	1939
2012-13	14.32	2532	77471	1969
2013-14	15.62	2487	61714	1520
2014-15	16.712	1883	60679	1643
2015-16	18.81	2206	62089	1671

Annexure 6 (Production (MT) and Productivity (MT/Ha) of Paddy)

Year	Aizawl		Champhai		Kolasib		Lawngtlai	
	Prod. in MT.	Productivity	Prod. in MT.	Productivity	Prod. in MT.	Productivity	Prod. in MT.	Productivity
2005-06	10,333	102	13,172	126	12,106	143	7,92,007	14,048
2006-07	1404	16	5370	39	2812	40	3023	43
2007-08	1404	16	5370	39	2812	40	3023	43
2008-09	3497.4	53	12699.85	134	5451.12	81	2105.81	52
2009-10	4572.08	86	11540.75	145	6184.1	115	3356.03	64
2010-11	5091	97	12579	155	8196	131	3494	67
2011-12	5319	120	11643	155	9443	156	5987	107
2012-13	5678	139	15195	154	9923	161	7710	133
2013-14	5270	141	15780	158	10160	167	8936	144
2014-15	6310	161	13737	156	10865	185	10307	175
2015-16	6396	162	14910	169	10966	190	9672	166

Annexure 7 (Production (MT) and Productivity (MT/Ha) of Paddy)

Year	Lunglei		Mamit		Saiha		Serchhip	
	Prod. in MT.	Productivity	Prod. in MT.	Productivity	Prod. in MT.	Productivity	Prod. in MT.	Productivity
2005-06	10,630	127	7,649	144	5,254	119	5,122	138
2006-07	595	12	974	25	475	8	1035	30
2007-08	595	12	974	25	475	8	1035	30
2008-09	5816.27	67	6375.05	75	483.07	25	9745.82	160
2009-10	6986.76	87	7482.56	101	1111.53	58	3075.3	52
2010-11	5562	108	1494	33	1387	93	6390	150
2011-12	6618	132	6343	115	1976	139	5566	162
2012-13	5934	141	4241	113	2384	169	6635	163
2013-14	1661	333	1126	149	562	226	1139	75
2014-15	6347	152	4397	139	1596	150	7120	174
2015-16	5935	142	4860	147	1756		7594	180