Precipitation and its Impacts for Global Scale Rice Production

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ABSTRACT**:** Rice plays a major role in the global supply and demand for sustainable food production. Rice production has consistently outpaced population growth. Thus, rice plays a crucial role in supporting continued global population growth. The progress of technology, irrigation and rice varieties made it possible for farmers to produce more rice with tolerance for climate change. In 1992, because of abnormal climatic conditions, the yield of rice in Japan fell to less than 90% that of annual average production, where the technology for agriculture is thought to be well developed. At that time, Japan had to import rice. Thus the impact of climate change cannot be ignored. When discussing yield of rice, the impact of climatic conditions should be discussed. In this study, we focused on the relationships between yield of rice and precipitation datasets. Monthly precipitation datasets are provided from Global Precipitation Climatology Centre in Germany (hereafter we called "GPCC"). The resolution of GPCC is 0.5 degree and from west to east, numbers of columns are 720 and from north to south, numbers of rows are 360 and covers from January 1900 to December 2007. Datasets from January 1981 to December 2003 are used to calculate the country based relationships in this study. The Cropping Calendar dataset includes spatial information and provides five patterns such as Planting, Vegetative, Heading, Filling and Harvesting. The resolution of the cropping calendar is almost the same that of GPCC. According to the cropping calendar, the lifecycle of rice which includes five patterns in each country is obtained. Single regression analysis is used to calculate the relationships among time series of monthly precipitation datasets and yield of rice. In another words, yield of rice is a function of GPCC. Due to data limitations and variety of resolutions of datasets, we could only use country based datasets to obtain the equations. The country based rice production per unit area in each country is calculated by dividing the rice production figures provided by the Food and Agriculture Organization (FAO) by the rice cultivation area.

KEYWORDS: Yield, Cropping Calendar, Precipitation

1. INTRODUCTION

More than 50% of world population lives in Asia and relies on rice production. Rice plays an important role. In 1962, Asian farmers produced 92% of world rice production. Rice producing system is steady. According to Food Balance Sheet (year 2002), use of rice as animal feed is less than 1.8% of total production (IRRI 2008). World rice production in 2007 was approximately 645 million tones, with Asian farmers producing 90% and China and India producing 50% of the global rice supply (Kawashima 2008). The top 5 rice producing countries are China, India, Indonesia, Bangladesh, Vietnam and Thailand. In Asian countries, governments buy rice from farmers or from international market and they provide rice to citizens with the price lower than that of government payment. This policy plays a very important role to stabilize society. The amount of rice on international market is not so large, This sometimes causes fluctuations of price. In 2009, Philippine was attacked by several typhoons and reduced the production of rice. In 2009, Philippine has decided to import rice from Vietnam around 2.05 million tons of rice. India also could produce 20% less production of rice than previous year, because of shortage of water. In this paper, we will focus on the relationships between yield of rice and precipitation. As for the precipitation, we concern the cropping calendar. If planting of rice begins in April and harvesting starts in September, total amount of precipitation from April to August is calculated and use to calculate the relationships with yield of rice country basis. The precipitation datasets are provided in gridded level, so we apply country based obtained equation for gridded precipitation datasets and as a result, spatial distribution of yield of rice could be obtained. In this study, the relationships between precipitation and yield in Japan is proposed.

2. Materials

2.1 Administrative Boundary Data

ESRI company provides administrative boundary datasets. For example, Japan is composed by 6 areas such as Hokkaido, Tohoku, Kanto, Chubu, Hokuriku, Kinki, Chugoku, Sikoku and Kyushu.

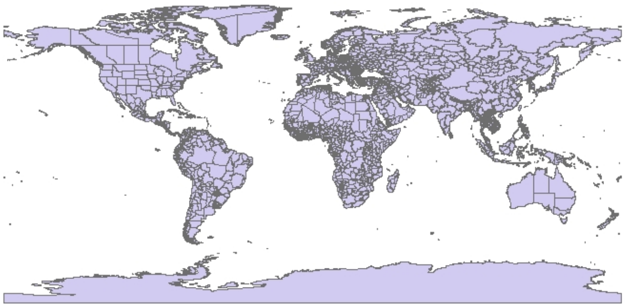

Figure 1 Administrative Boundary

2.2 Yield per unit area Data

We calculated the rice production per unit area in each country, by dividing the rice production figures provided by the Food and Agriculture Organization (FAO) by the rice cultivation area. We then applied the yield per unit area for each country uniformly to each of the regions in that country.

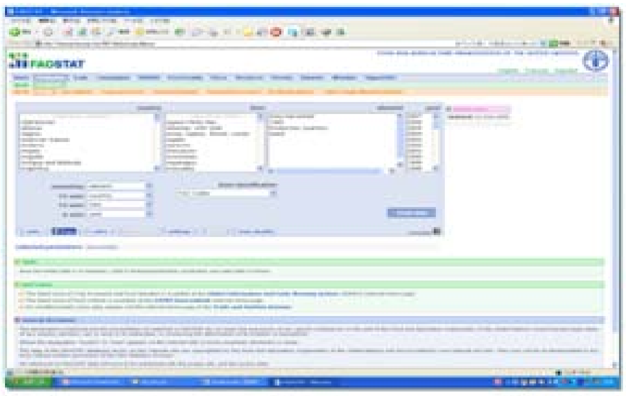

Figure 2 FAOSTAT web-site

2.3 Precipitation Data

We used precipitation datasets shown in figure 3. Monthly precipitation datasets are provided from Global Precipitation Climatology Centre in Germany (hereafter we called "GPCC"). The resolution of GPCC is 0.5 degree and from west to east, numbers of columns are 720 and from north to south, numbers of rows are 360 and covers from January 1900 to December 2007. Each dataset consists of 3 columns such as column 1 : precipitation totals in mm/month, column 2 : deviation from normals v2008 in mm/month and column 3 : number of gauges per grid. We used precipitation totals in mm month.

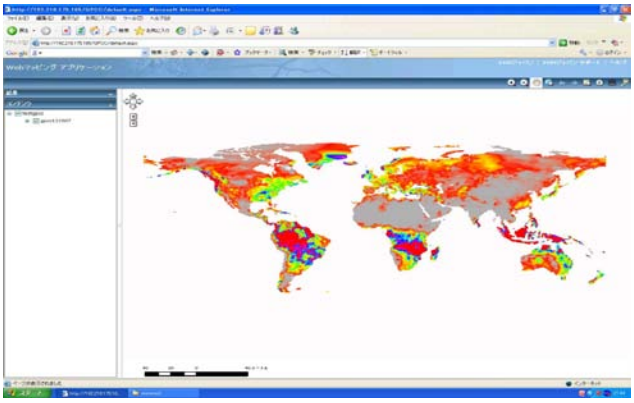

Figure 3 Global Precipitation Datasets

2.4 Vegitation Data

We used Vegitation Data sets developed by global mapping project. Figure 4 shows the overall of vegetation map. The resolution is 1km and includes 20 legends shown in Table 1.

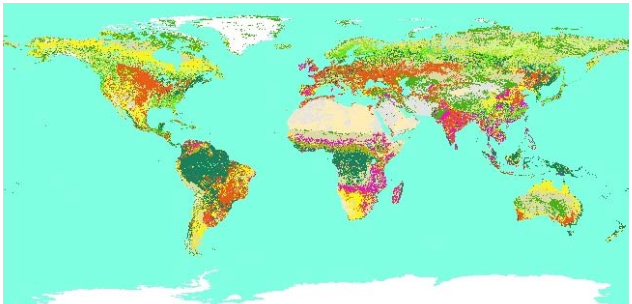

Figure 4 Global Land Cover (GLCNMO) Data

Table 1 Legend of Land Use and Land Cover

code	Class name	code	Class name	code	Class name	code
1	Broadleaf Evergreen Forest	6	Tree Open	11	Cropland	16
2	Broadleaf Deciduous Forest	7	Shrub	12	Paddy field	17
3	Needleleaf Evergreen Forest	8	Herbaceous	13	Cropland / Other Vegetation Mosaic	18
4	Needleleaf Deciduous Forest	9	Herbaceous with Sparse Tree/Shrub	14	Mangrove	19
5	Mixed Forest	10	Sparse vegetation	15	Wetland	20

In the legends, rice field is included and this will help us to understand the distribution of paddy field. Paddy field can be observed mainly in Asian countries. Cropland (Legend=11) is shown in Figure 5. Paddy Field(Legend=12) is shown Figure 6 and Cropland/Other vegetation Mosaic(Legend=13) is shown in Figure 7.

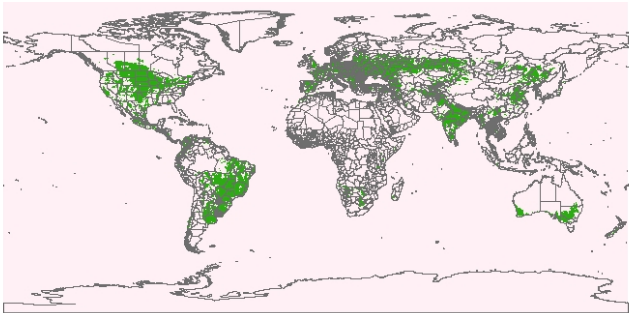

Figure 5 Cropland

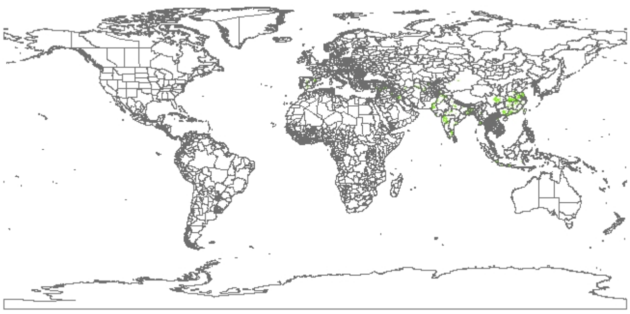

Figure 6 Paddy Field

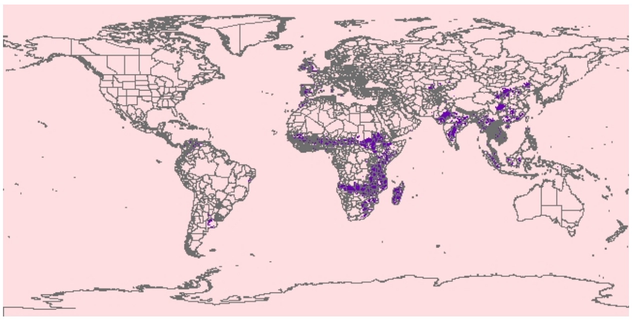

Figure 7 Cropland/Other vegetation Mosaic

2.5 Cropping Calendar

We used cropping calendar datasets to calculate the relationships between yield and precipitation. Wisconsin University provides cropping calendar data set including gridded maps of planting dates, harvesting dates and related variables.

3. Data Analysis

3.1 Cropping Calendar of Rice

Crops process four patterns such as Planting, Vegitative, Heading and Filling. Table 2 shows the list of cropping calendar of rice in each country. The total number of countries are 182.

Table 2 Cropping Calendar of Rice

	PlantStart	PlantRange	HarvestStart	HarvestEnd
Falkland Is.	284	71	71	131
French Guiana	314	172	121	293
Guyana	101	42	253	324
South Georgia & t	274	80	70	151
Suriname	71	163	253	294
Trinidad & Tobag	152	72	294	344
Venezuela	99	102	222	323
Samoa	284	134	111	202
Argentina	335	90	121	212
Bolivia	242	108	59	175
Brazil	305	30	70	141
Chile	109	67	103	207
Ecuador	284	71	71	132
Paraguay	281	133	112	203
Peru	279	72	71	142
Uruguay	341	102	131	233
Canada	274	80	69	151
Guatemala	113	46	256	305
Mexico	91	91	244	297
Dominica	101	102	253	20
Martinique	152	72	294	344
Dominican Repub	335	121	121	243
Haiti	79	94	147	268
Jamaica	105	134	177	332
The Bahamas	60	134	193	365
Belize	91	91	244	304
Colombia	40	42	223	293
Costa Rica	91	61	213	273
Cuba	60	134	193	365
El Salvador	121	61	305	31
Honduras	166	61	254	199
Nicaragua	151	31	273	333
Panama	102	101	222	293
Puerto Rico	32	89	152	273
Faroe Is.	95	54	269	310
Greenland	92	55	267	309
Iceland	95	54	269	310
Ireland	80	56	263	308
Isle of Man	95	54	269	310
United Kingdom	152	61	274	334
Cape Verde	93	121	242	363
Cote d'Ivoire	104	74	257	330
Ghana	91	122	244	365
Liberia	70	71	228	281
Morocco	24	65	241	301
Portugal	24	65	241	301
Spain	92	58	180	253
Western Sahara	330	32	65	122
Burkina Faso	121	123	274	31
Guinea	149	95	274	31
Guinea-Bissau	153	61	317	33
Mali	152	46	274	332

Table 2 Cropping Calendar of Rice (Continue)

	PlantStart	PlantRange	HarvestStart	HarvestEnd
Mauritania	152	91	305	35
Senegal	91	122	244	365
Sierra Leone	152	71	284	233
The Gambia	182	62	305	334
Djibouti	199	62	281	310
Eritrea	172	60	299	328
Ethiopia	104	52	235	287
Mongolia	157	80	299	338
Sudan	212	62	267	297
Uganda	106	46	258	287
Iraq	134	44	234	282
Israel	101	41	253	304
Jordan	132	23	252	274
Kazakhstan	95	54	269	310
Norway	110	40	253	291
Russia	95	54	269	310
Sweden	101	41	253	304
West Bank	72	102	254	294
Algeria	121	92	304	365
Cameroon	121	123	319	365
Central African R	106	73	231	266
Libya	72	102	254	294
Tunisia	93	59	217	275
Benin	152	61	213	334
Chad	263	71	87	159
Equatorial Guinea	152	61	213	334
Niger	133	61	276	346
Nigeria	284	72	71	141
Togo	121	31	289	319
Albania	111	41	213	243
Bosnia & Herzego	111	41	213	243
Croatia	103	48	241	277
Italy	95	54	269	310
Macedonia	111	41	213	243
Serbia & Montene	111	41	213	243
Bulgaria	108	50	225	258
Cyprus	101	41	253	304
Egypt	113	82	282	322
Georgia	101	40	252	302
Greece	110	44	216	247
Lebanon	101	41	253	304
Syria	101	42	253	304
Turkey	101	72	254	293
Austria	95	54	269	310
Czech Republic	95	54	269	310
Denmark	95	54	269	310
Hungary	109	43	221	252
Poland	101	49	249	286
Slovakia	107	45	228	261
Slovenia	95	54	269	310
Svalbard	95	54	269	310
Belgium	95	54	269	310
France	85	55	265	309
Germany	95	54	269	310
Luxembourg	95	54	269	310
Netherlands	95	54	269	310
Switzerland	95	54	269	310
United States	110	48	249	302
Belarus	107	53	228	262
Estonia	101	49	248	285
Finland	95	54	269	310
Latvia	105	46	235	270
Lithuania	106	45	232	265
Moldova	102	70	251	290
Romania	109	46	220	251
Ukraine	103	65	244	281
India	157	44	285	322
Oman	139	38	252	290

Table 2 Cropping Calendar of Rice (Continue)

	PlantStart	PlantRange	HarvestStart	HarvestEnd
Somalia	127	62	218	279
Sri Lanka	244	111	10	111
Turkmenistan	104	16	225	242
Uzbekistan	116	28	238	271
Yemen	164	52	289	325
Armenia	101	34	246	287
Azerbaijan	101	14	224	237
Iran	101	12	222	232
Kuwait	106	46	258	288
Qatar	134	35	239	273
Saudi Arabia	182	12	324	334
United Arab Emir	136	34	243	276
Afghanistan	137	62	262	343
Kyrgyzstan	169	35	288	322
Nepal	142	82	294	353
Pakistan	139	66	264	352
Tajikistan	156	48	278	335
Bangladesh	151	72	303	360
Bhutan	137	82	288	347
Brunei	161	103	344	109
China	87	64	209	270
Japan	132	71	258	324
North Korea	101	31	254	293
Philippines	91	79	254	349
South Korea	121	61	244	304
Cambodia	152	138	335	59
Laos	137	65	275	346
Malaysia	201	68	118	111
Myanmar	121	65	277	352
Thailand	128	116	279	38
Vietnam	160	93	286	190
Botswana	253	102	100	171
Burundi	335	62	121	151
French Southern &	253	102	100	171
Heard I. & McDo	91	61	274	334
Kenya	335	62	121	151
Rwanda	141	58	158	222
Tanzania	288	75	101	176
Zambia	274	92	91	181
Zimbabwe	251	62	89	161
Antarctica	305	77	91	181
Lesotho	253	102	100	171
Malawi	314	52	121	192
Mozambique	300	59	97	181
South Africa	253	102	100	171
Swaziland	284	41	10	140
Angola	284	72	71	141
Congo	257	81	155	205
Congo, DRC	275	62	193	222
Fiji	335	90	121	212
Gabon	286	71	87	151
Namibia	254	100	99	170
New Zealand	274	31	60	151
Madagascar	305	77	91	181
Reunion	305	77	91	181
Indonesia	305	77	91	181
Timor Leste	252	64	74	138
Australia	335	90	121	212
New Caledonia	294	40	90	161
Papua New Guine	335	90	121	212
Solomon Is.	328	84	109	194
Vanuatu	335	90	121	212

3.2 Integration of Precipitation and Yield

Based on cropping calendar, the precipitin data is aggregated the periods between Planting to Heading and Filling. According to cropping calendar shown in Table 2, in Japan, Planting(April), Vegetative (May, June) and Heading and Filling (July and August, September). the precipitation from April to September is aggregated. When those data is aggregated, total days in month is also important, the number of cropping days are also calculated and applying for calculating total population. Single regression analysis is applied for calculating relationships between aggregated monthly precipitation and yield. Table 3 shows a result of relationships between precipitation and yield by country basis. Elasticity, Constant, Co-relation coefficient and significance are listed in Table 3. "0" means the countries where rice are not harvested.

Table 3 Relationships between Precipitation and Yield

	Aggrigated Month	Time Length	Regression Coefficient	Constant	Multiple Correlation	Significance	P Value
Falkland Is.							
French Guiana	Oct_Apr	1983/2003	-1.340931	36135.842	0.0690296	[ ]	0.76622
Guyana	Mar_Aug	1981/200	8.3284489	24584.458	0.396056	[ ]	0.06805
South Georgia & the South Sandwich	0	0	0	0	0	0	0.00000
Suriname	0	0	0	0	0	0	0.00000
Trinidad & Tobago	0	0	0	0	0	0	0.00000
Venezuela	0	0	0	0	0	0	0.00000
Samoa	0	0	0	0	0	0	0.00000
Argentina	Nov_Apr	1982/200	33.127229	30502.764	0.5019178	[*]	0.01730
Bolivia	Aug_Feb	1982/200	-11.64159	29290.244	0.3148102	[ ]	0.15358
Brazil	Oct_Feb	1982/200	-19.32364	40479.7	0.588109	[**]	0.00399
Chile	Mar_Jul	1981/200	11.001526	36968.853	0.3838405	[ ]	0.07058
Ecuador	Sep_Feb	1982/200	-3.687809	35670.864	0.2028642	[ ]	0.36523
Paraguay	Sep_Mar	1982/200	18.174371	13439.048	0.3653367	[ ]	0.09454
Peru	Sep_Feb	1982/200	4.8417756	50512.961	0.0660927	[ ]	0.77011
Uruguay	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Canada	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Guatemala	Apr_Jul	1981/200	-0.02044	27389.657	0.000976	[ ]	0.99647
Mexico	Mar_Jul	1983/200	12.574093	36756.88	0.1769978	[ ]	0.41913
Dominica	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Martinique	0	0	0	0	0	0	0.00000
Dominican Republic	Nov_Mar	1982/2003	7.5241825	43360.734	0.2556817	[ ]	0.25078
Haiti	Feb_Apr	1981/200	5.8810841	20214.63	0.3405007	[ ]	0.11187
Jamaica	Mar_May	1981/200	8.9389216	20040.031	0.1331819	[ ]	0.54464
The	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Belize	Mar_Aug	1981/200	9.5102352	12333.189	0.3658538	[ ]	0.08601
Colombia	Jan_Jul	1981/200	-5.738965	53624.3	0.3936487	[ ]	0.06311
Costa Rica	Mar_Jun	1981/200	-2.252931	38717.048	0.0747089	[ ]	0.73477
Cuba	Feb_Jun	1981/200	-10.84703	35101.146	0.2113711	[ ]	0.33296
El Salvador	Apr_Sep	1981/200	4.1644855	40505.488	0.0817137	[ ]	0.71090
Honduras	Feb_Aug	1981/200	-2.716447	28080.338	0.1088199	[ ]	0.62113
Nicaragua	May_Aug	1981/200	4.3714371	28897.15	0.2366966	[ ]	0.27686
Panama	Mar_Jul	1981/200	-2.118122	23431.75	0.3231648	[ ]	0.13255
Puerto	Jan_Apr	1981/198	-164.6421	116072.99	0.3813364	[ ]	0.31124
Faroe Is.	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Greenland	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Iceland	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944

Table 3 Relationships between Precipitation and Yield (Continue)

	Aggregate d Month	Time Length	Regression Coefficient	Constant	Multiple Correlatio n	Significance	P Value
Ireland	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Isle of Man	0	0	0	0	0	0	0.00000
United Kingdom	0	0	0	0	0	0	0.00000
Cape	0	0	0	0	0	0	0.00000
Cote	Mar_Aug	1981/200	-5.133293	17296.509	0.3783131	[ ]	0.07508
Ghana	Mar_Jul	1981/200	-8.976133	21181.881	0.2347823	[ ]	0.28088
Liberia	Feb_Jul	1981/200	0.7495651	10838.486	0.1427386	[ ]	0.51588
Morocco	Feb_Jul	1981/200	-7.556966	45127.387	0.0330235	[ ]	0.88109
Portugal	Feb_Jul	1981/200	-8.106182	53739.363	0.0842094	[ ]	0.70245
Spain	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Western Sahara	Oct_Apr	1983/200 3	-1.282703	36481.453	0.069967	[ ]	0.76944
Burkina	Apr_Aug	1981/200	6.9624374	15664.454	0.2466625	[ ]	0.25653
Guinea	May_Aug	1981/200	-0.096541	17219.15	0.3984742	[ ]	0.05966
Guinea-Bissau	May_Sep	1981/200 3	6.1868403	9945.7908	0.2843926	[ ]	0.18845
Mali	May_Aug	1981/200	3.1689437	14895.887	0.244078	[ ]	0.26171
Mauritania	May_Sep	1981/200	7.2752485	40207.984	0.1429917	[ ]	0.51512
Senegal	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Sierra	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
The	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Djibouti	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Eritrea	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Ethiopia	Mar_Jul	1993/200	-0.196185	18497.032	0.0721607	[ ]	0.83301
Mongolia	0	0	0	0	0	0	0.00000
Sudan	0	0	0	0	0	0	0.00000
Uganda	0	0	0	0	0	0	0.00000
Iraq	Apr_Jul	1981/200	-8.432106	23720.064	0.0479917	[ ]	0.82786
Israel	0	0	0	0	0	0	0.00000
Jordan	0	0	0	0	0	0	0.00000
Kazakhsta	Mar_Aug	1992/200	7.247922	29140.356	0.1247713	[ ]	0.69923
Norway	0	0	0	0	0	0	0.00000
Russia	0	0	0	0	0	0	0.00000
Sweden	0	0	0	0	0	0	0.00000
West Bank	0	0	0	0	0	0	0.00000
Algeria	Apr_Sep	1981/200	65.048423	21211.457	0.244941	[ ]	0.25997
Cameroon	Apr_Sep	1981/200	12.907121	21304.628	0.3888578	[ ]	0.06668
Central African Republic	Mar_Jul	1981/200 3	-2.962965	16616.28	0.086506	[ ]	0.69471
Libya	0	0	0	0	0	0	0.00000
Tunisia	0	0	0	0	0	0	0.00000
Benin	May_Jul	1981/200	-7.164988	18320.255	0.2135482	[ ]	0.32789
Chad	Sep_Mar	1982/200	-0.408269	13442.724	0.0047948	[ ]	0.98310
Equatorial Guinea	0	0	0	0	0	0	0.00000
Niger	Apr_Aug	1981/200	9.6282951	26708.249	0.1412216	[ ]	0.52039
Nigeria	Oct_Feb	1982/200	-21.27195	20967.829	0.5978675	[**]	0.00330
Togo	0	0	0	0	0	0	0.00000
Albania	Apr_Jun	1981/199	-8.344909	35047.531	0.0844904	[ ]	0.78375
Bosnia & Herzegovin	0	0	0	0	0	0	0.00000
Croatia	0	0	0	0	0	0	0.00000
Italy	Mar_Aug	1981/200	-8.514121	61690.473	0.1470604	[ ]	0.50311
Macedonia	0	0	0	0	0	0	0.00000
Serbia & Montenegr	0	0	0	0	0	0	0.00000
Bulgaria	Mar_Jul	1981/200	7.5424164	36047.719	0.1107832	[ ]	0.61481
Cyprus	0	0	0	0	0	0	0.00000
Egypt	Apr_Aug	1981/200	73.61479	73133.709	0.1737739	[ ]	0.42779
Georgia	0	0	0	0	0	0	0.00000
Greece	Apr_Jun	1981/200	-16.87773	68332.123	0.0600876	[ ]	0.78536
Lebanon	0	0	0	0	0	0	0.00000
Syria	0	0	0	0	0	0	0.00000
Turkey	0	0	0	0	0	0	0.00000
Austria	0	0	0	0	0	0	0.00000
Czech Republic	0	0	0	0	0	0	0.00000
Denmark	0	0	0	0	0	0	0.00000
Hungary	Apr_Jun	1983/200	6.1350444	31244.432	0.0679533	[ ]	0.75803
Poland	0	0	0	0	0	0	0.00000
Slovakia	0	0	0	0	0	0	0.00000
Slovenia	0	0	0	0	0	0	0.00000
Svalbard	0	0	0	0	0	0	0.00000
Belgium	0	0	0	0	0	0	0.00000
France	Mar_Aug	1981/200	-18.95181	60126.278	0.2085839	[ ]	0.33952
Germany	0	0	0	0	0	0	0.00000
Luxembour	0	0	0	0	0	0	0.00000
Netherland	0	0	0	0	0	0	0.00000
Switzerlan	0	0	0	0	0	0	0.00000
United	0	0	0	0	0	0	0.00000

Table 3 Relationships between Precipitation and Yield (Continue)

	Aggregate d Month	Time Length	Regression Coefficient	Constant	Multiple Correlatio n	Significance	P Value
Belarus	0	0	0	0	0	0	0.00000
Estonia	0	0	0	0	0	0	0.00000
Finland	0	0	0	0	0	0	0.00000
Latvia	0	0	0	0	0	0	0.00000
Lithuania	0	0	0	0	0	0	0.00000
Moldova	0	0	0	0	0	0	0.00000
Romania	Apr_Jun	1981/199	-33.77344	33732.642	0.1517754	[ ]	0.57471
Ukraine	0	0	0	0	0	0	0.00000
India	May_Sep	1981/200	0.4582602	25456.483	0.0224847	[ ]	0.91889
Oman	0	0	0	0	0	0	0.00000
Somalia	0	0	0	0	0	0	0.00000
Sri Lanka	0	0	0	0	0	0	0.00000
Turkmenist	0	0	0	0	0	0	0.00000
Uzbekistan	0	0	0	0	0	0	0.00000
Yemen	0	0	0	0	0	0	0.00000
Armenia	0	0	0	0	0	0	0.00000
Azerbaijan	Mar_Jul	1992/200	-2.949947	38757.381	0.0199616	[ ]	0.92797
Iran	Mar_Jul	1981/200	2.2792053	25760.534	0.2284402	[ ]	0.29445
Kuwait	0	0	0	0	0	0	0.00000
Qatar	0	0	0	0	0	0	0.00000
Saudi	0	0	0	0	0	0	0.00000
United Arab	0	0	0	0	0	0	0.00000
Afghanista	Apr_Aug	1981/200	-0.835507	21455.168	0.0089873	[ ]	0.96754
Kyrgyzstan	Aug_Sep	1992/200	-41.50226	27289.984	0.3035121	[ ]	0.33754
Nepal	Apr_Sep	1981/200	1.6429748	20390.925	0.1179787	[ ]	0.59187
Pakistan	Apr_Aug	1981/200	2.2792053	25760.534	0.2284402	[ ]	0.29445
Tajikistan	0	0	0	0	0	0	0.00000
Banglades	May_Sep	1981/200	-5.396816	35023.025	0.4800564	[*]	0.02043
Bhutan	May_Sep	1981/200	-2.562535	20770.804	0.2513865	[ ]	0.24724
Brunei	May_Nov	1981/200	7.456899	2666.5706	0.5442355	[**]	0.00726
China	Mar_Jun	1981/200	12.273833	54019.985	0.3128649	[ ]	0.14607
Japan	Apr_Aug	1981/200	-9.493868	67686.183	0.2999194	[ ]	0.16441
North	Mar_Sep	1981/200	-12.63678	51055.649	0.2046807	[ ]	0.34884
Philippines	Mar_Aug	1981/200	6.6437107	21589.215	0.5872908	[**]	0.00322
South	Apr_Jul	1981/200	0.6801633	62908.773	0.0301775	[ ]	0.89128
Cambodia	May_Oct	1981/200	5.4412076	6919.4934	0.5341	[**]	0.00866
Laos	Apr_Aug	1981/200	10.278694	11402.738	0.2836422	[ ]	0.18966
Malaysia	Jun_Mar	1982/200	-0.217223	29105.552	0.0272762	[ ]	0.90657
Myanmar	Apr_Aug	1981/200	-1.546186	33234.846	0.38668	[ ]	0.06835
Thailand	0	0	0	0	0	0	0.00000
Vietnam	0	0	0	0	0	0	0.00000
Botswana	0	0	0	0	0	0	0.00000
Burundi	Nov_Mar	1982/200	6.4092029	26744.632	0.1702949	[ ]	0.44864
French Southern & Antarctic Lands	0	0	0	0	0	0	0.00000
Heard I. & McDonald	0	0	0	0	0	0	0.00000
Kenya	Nov_Mar	1982/200	5.6579339	35777.918	0.1764092	[ ]	0.43226
Rwanda	0	0	0	0	0	0	0.00000
Tanzania	0	0	0	0	0	0	0.00000
Zambia	0	0	0	0	0	0	0.00000
Zimbabwe	0	0	0	0	0	0	0.00000
Antarctica	0	0	0	0	0	0	0.00000
Lesotho	0	0	0	0	0	0	0.00000
Malawi	Oct_Mar	1982/200	2.1305377	14416.499	0.1678069	[ ]	0.45539
Mozambiq	Oct_Feb	1981/200	0.3389122	8132.4078	0.0347736	[ ]	0.87790
South	Oct_Apr	1981/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Swaziland	0	0	0	0	0	0	0.00000
Angola	Oct_Jan	1982/200	12.798295	4831.1057	0.2429933	[ ]	0.27587
Congo	Sep_Apr	1982/200	2.5346575	5596.6945	0.1568594	[ ]	0.48573
Congo,	Sep_May	1982/200	0.0262321	7741.3265	0.0188634	[ ]	0.93360
Fiji	Nov_Mar	1982/200	6.2834638	19219.851	0.3336679	[ ]	0.12912
Gabon	Oct_Feb	1982/200	1.2143925	19454.67	0.0907344	[ ]	0.68800
Namibia	Oct_Apr	1983/200	0	0	0	0	0.00000
New	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Madagasc	Oct_Feb	1982/200	2.1889983	18406.856	0.2212633	[ ]	0.32238
Reunion	0	0	0	0	0	0	0.00000
Indonesia	Oct_Feb	1982/200	-1.806324	43962.203	0.1052998	[ ]	0.66790
Timor	0	0	0	0	0	0	0.00000
Australia	Nov_Mar	1982/200	17.446029	72052.529	0.0999339	[ ]	0.68397
New Caledonia	Oct_Apr	1983/200 3	0	0	0	0	0.00000
Papua New	Nov_Mar	1982/200 0	4.117269	14128.412	0.2189715	[ ]	0.36776
Solomon	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944
Vanuatu	Oct_Apr	1983/200	-1.282703	36481.453	0.069967	[ ]	0.76944

4. Results and Discussion

Precipitation datasets with spatial information are aggregated by country and average precipitation in each country is obtained. Monthly precipitation is aggregated based on cropping calendar. The relationships between precipitation and yield of rice are calculated for rice producing countries. Extracting from results shown in Table 3, Table 4 shows the results of those countries with significance.

Table 4 Relationships between Precipitation and Yield with significance

	Aggregated Month	Time Length	Regression Coefficient	Constant	Multiple Correlation Coefficient	Signicicanse
Argentina	Nov_Apr	1982/200:	33.127229	30503	0.50192	[*]
Brazil	Oct_Feb	1982/200:	-19.32364	40480	0.58811	[**]
Nigeria	Oct_Feb	1982/200:	-21.27195	20968	0.59787	[**]
Bangladesh	May_Sep	1981/200:	-5.396816	35023	0.48006	[*]
Brunei	May_Nov	1981/200:	7.456899	2667	0.54424	[**]
Philippines	Mar_Aug	1981/200:	6.6437107	21589	0.58729	[**]
Cambodia	May_Oct	1981/200:	5.4412076	6919	0.53410	[**]

The rice yield in Argentina, Brazil, Nigeria, Bangladesh, Brunei, Philippines and Cambodia could be influenced by precipitation. In another word, irrigation system or reserving water system are not well equipped, or we might say those countries might attacked by typhoons. Very simple way but we will be able to build a system which can forecast rice yield. Putting precipitation dataset on this formula and we might forecast yield of rice. When discussing yield of rice, the impact of climatic conditions should be discussed. Establishing forecasting system of rice production is an urgent matter and those information should be open to the public in an easier manner. Those countries without significance, we have to progress our study on other valuables. There are also another factor such as NDVI (Normalized Vegitation Index), but we will discuss about this in another paper.

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