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DETERMINATION OF CROPPING PATTERN BASED ON WATER SURFACE ELEVATION OF WEIR USING MATHEMATICAL METHOD

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Abstrak. Empangan merupakan tempat penyimpanan air sementara selama ada kelebihan air dan segera dikeluarkan apabila diperlukan. Ada tiga faktor utama yang harus diperhatikan bagi mencapai penggunaan air secara optimum iaitu kapasitas empangan, curahan hujan dan pola tanaman yang digunakan. Curahan hujan adalah gejala alam yang dapat diperhitungkan dari data meteorologi yang tersedia. Pola tanaman hanyalah faktor yang dapat ditentukan oleh manusia. Kajian ini akan membahaskan tentang pengiraan pola tanaman yang akan digunakan dengan membaca paras muka air empangan dari pemodelan matematik yang telah dibuat dalam bentuk grafik. Dengan membandingkan data muka air terkini dapat digunakan untuk menentukan pola tanam berikutnya.

Kata kunci: pola tanaman, elevasi muka air

Abstract. A weir is temporary water storage when it is excessive during rainy session, and it is drawn out during dry season to meet water demand in the field. There are three important parameters which are affecting the volume of water in the reservoir, i.e., rainfall, cropping pattern, and the reservoir's capacity. Those three parameters have to be equally balanced as indicated by water level in the weir never spill out or never below the intake elevation. The rainfall is the natural phenomenon that can be predicted by meteorogical data available, while the weir capacity is varied according to the seasons. The cropping pattern is the only factor which can be interfered by human. This study is aiming to predict the crop pattern by monitoring water elevation. Mathematical modelling is presented graphically. By comparing it to the plotting of recent water level data, could be cosidered to predict for the next crop.

Keywords: cropping pattern, water surface elevation

1.0 INTRODUCTION

1.1 Background

A weir constitutes temporary water storage during the excessive water exist and it will be drained off soon if needed. For the purpose of power generation water must be supplied continuously whereas for irrigation purpose water, is drained out only when the plant needs. On this paper, it is only discussed the weir water utilization for plant. Water utilization is considered optimum if irrigation demand may be fulfilled and if there is no runoff spillway in wet season.

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There are three parameters required in order to achieve optimum water utilization: storage behing the weir, rainfall, and cropping pattern. Those parameter should be in balance each other, and if one or more of those parameter are not accordance with others, optimum water utilization will not be achieved.

Rainfall is used for planning and hydrological formulas are employed. Basically, in this paper rainfall is predicted based on available rainfall records and then the predicted rainfall is used to forecast run off.

The kind of plant discussed in this study comprises of paddy and palawija. The variation of plant constitutes cropping pattern that should suited with rainfall and weir storage capacity accordingly.

The failure in determining cropping pattern will reduce crop production, and cause plant mortality. In this paper method of distribution of cropping pattern considered and related to water surface elevation of the weir storage only by reading the graphical water. The type of cropping pattern adopted will affect water availability in paddy field. As paddy needs more water compared with palawija, the double cropping pattern in a year will fastly reduced storage behind the weir.

1.2 Approach Methods

Based on the weir storage water balance calculation for varying cropping pattern and will minimum rainfall, the rate of storage behind the weir is worked out. Water surface level of initial planting is prepared and that of next planting can be predicted.

1.3 Purpose of Study

The aim of study is to investigate the correlation between cropping pattern and water surface level for minimum rainfall events using weir storage used paddy field, and moreover, the fittest cropping pattern related to water surface elevation for weir storage.

2.0 METHODOLOGY

The study is carried out by using mathematical model, which is aimed at determining the water volume fluctuation for weir storage including filling and draining. Cropping pattern is initially determined, then water balance calculation is performed by aquiring rainfall data and minimum rainfall values are selected. Correlation between volume, area, and elevation of weir storage water surface is determined by considering the evaporation, chart correlating time, weir storage water surface elevation, chart cropping pattern.

The area of study is located in Lamongan District, East Java. Some data collected from weir include watershed what feeding the storage behind the weir, correlation among volume, area and water surface elevation of weir. Data collected from the paddy field include area of paddy field, the preferred cropping pattern, and the existing irrigation system. Information about the characteristics of plant is also needed such as planting coefficient, plant age and plant growth stages.

3.0 DATA ANALYSIS

Data analysis is directed to obtain data of inflow, evaporation rate and irrigation schedule. The data can be used to calculate weir storage water. Data obtained will be analysed to determine inflow outflow for weir storage. Furthermore, the water storage of weir is affected by weir dimensions.

3.1 The storage of inflow water

For the weir, the rate of inflow water is determined by rainfall, coefficient of catchment area and watershed (8.912.500 m^2). The rainfall for cropping pattern of paddy and palawija is 907 mm/year that being distributed with 10 days periods based on rainfall data from 1962 until 1984. The rainfall and storage inflow water is presented in Table 1.

Table 1 Rain fall and storage inflow (area of watershed = 8912500 m^2)

Month	10-day periods	Rainfall distribution (mm)	Rainfall (mm/10 days)	Flow coefficient of catchment area	Inflow (m^3/10 days)
Nov	I	31	18,85	0,40	67223
	II	41	24,47	0,44	95203
	III	52	31,02	0,48	132318
Dec	I	64	38,58	0,53	180883
	II	79	47,17	0,58	243648
	III	95	56,86	0,64	323848
Jan	I	88	52,91	0,59	279045
	II	87	52,42	0,58	271250
	III	86	51,43	0,57	260160
Feb	I	83	50,01	0,55	246344
	II	80	48,18	0,54	230375
	III	77	46,01	0,52	212821
Mar	I	72	43,53	0,50	194223
	II	68	40,81	0,48	175088
	III	63	37,88	0,46	155879
Apr	I	58	34,79	0,44	137005
	II	53	31,60	0,42	118821
	III	47	28,35	0,40	101616

(cont.)

Table 1 (*cont.*)

Month	10-day periods	Rainfall distribution (mm)	Rainfall (mm/10 days)	Flow coefficient of catchment area	Inflow (m^3/10 days)
May	I	42	25,08	0,38	85619
	II	36	21,85	0,36	70998
	III	31	18,70	0,35	57859
Jun	I	26	15,69	0,33	46259
	II	21	12,85	0,32	36203
	III	17	10,24	0,30	27661
Jul	I	13	7,91	0,29	20577
	II	10	5,90	0,28	14880
	III	7	4,26	0,28	10502
Aug	I	5	3,04	0,27	7395
	II	4	2,29	0,27	5551
	III	3	2,05	0,27	5021
Sep	I	4	2,38	0,28	5941
	II	6	3,32	0,29	8560
	III	8	4,92	0,30	13264
Oct	I	12	7,22	0,32	20605
	II	17	10,28	0,34	31341
	III	24	14,14	0,37	46460

3.2 The storage outflow water

Outflow water from weir consists of evaporation rate and irrigation demand. Evaporation values obtained from evaporation rate calculated from meteorologic data (see Table 2) and area of water surface that varies with the weir volume.

Catchment area contributing to the storage of the weir is obtained from the topographical map. By observing flooded area of weir and contour of weir correlation between volume, area and water surface elevation of weir can be obtained. In the case of weir, the correlation between area of water surface (L in m^2) and volume (V in m^3) is given by the following equation:

$$L = 2.10^{-13} \times V^3 + 5.10^{-10} \times V^2 + 0{,}3947 \times V + 3947{,}10 \quad ...(1)$$

and correlation between elevation (E) and area (L) of water surface of weir stated as:

$$E = 1{,}7072 \times LN(L) - 11{,}824 \quad ...(2)$$

Data from irrigation area and other data obtained previously will be used to determine irrigation demand. From field data it can be noticed that irrigation system turn into 7 groups in same area. Turning periods is 10 days. For the simplicity of calculation, all

Table 2 Evaporation data

Month	Period in 10 days	Evaporation (m/10 days)	Month	Period in 10 days	Evaporation (m/10 days)
Nov	I II III	0,07 0,07 0,07	May	I II III	0,06 0,06 0,06
Dec	I II III	0,07 0,07 0,07	Jun	I II III	0,06 0,06 0,06
Jan	I II III	0,07 0,07 0,07	Jul	I II III	0,06 0,07 0,07
Feb	I II III	0,06 0,06 0,06	Aug	I II III	0,07 0,07 0,07
Mar	I II III	0,06 0,06 0,06	Sep	I II III	0,07 0,07 0,07
Apr	I II III	0,06 0,06 0,06	Oct	I II III	0,07 0,07 0,07

data is based on 10 days periods. The most preferred crop is paddy, so that cropping pattern determination is carried out once a year.

Although irrigation area is 787 ha, but only 600 ha is applied for simplicity, and to overcome the difficulty in achieving optimum utilization of water using both paddy and palawija. Of land farm data the paddy age is 110 days, where the first 10 days of the age is used for seeding about 5% of total land of the farm area. Whereas the last 20 days is dry and no water is required. For palawija, it takes 90 days from planting to harvesting.

Referring to preceding experience the following information about paddy that should be taken into account:

- Percolation in dry season is 3 mm/day, while in wet season is 2 mm/day.
- Rainfall, which is more than 500-mm/10 day, considered 500 mm/day and for rainfall less than 50 mm/day considered absent (zero) and for 50 – 500 mm/day considered is fixed. The magnitude of effective rain is calculated 80 % of such rain fall.
- In heavy wet season, water loss in the farm is 5%, while in dry season is 10%

- Water demand for land treatment during seeding period in dry season is 150 mm/day, while in wet season is 100 mm/day.
- Water demand for land treatment of paddy in dry and wet season is 200 mm/day and 150 mm/day successively.

Meanwhile for palawija plantation the following should be considered:

- In dry season, the consumptive use is 90 mm/day if rainfall more than 90 mm/day, if the magnitutde is less than above, we use real existing data.
- In wet season we use effective rain fall of 70 mm/day if rainfall is more than 70 mm/day, if the number is less than the above, we use real existing data.
- In wet season, water loss in land farm is 10% and 15% in dry season
- During the passage of flow from weir to land farm we consider 15% water loss exist.

By observing plant age and time of initial wet season, the schedule of cropping pattern can be summarized in Table 3.

Table 3 Schedule of several types of cropping pattern

Cropping pattern			Plant start-up		Harvesting	
			group I	group II	group I	group II
	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr
I	600	ha paddy	10-Mar	10-May	30-Jun	30-Aug
	600	ha palawija	10-Jul	10-Sep	10-Oct	10-Dec
	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr
II	350	ha paddy and	10-Mar	10-May	30-Jun	30-Aug
	250	ha palawija	10-Mar	10-May	01-Jun	01-Aug
	600	ha palawija	01-Jul	01-Sep	01-Oct	01-Dec
	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr
III	600	ha paddy	10-Mar	10-May	30-Jun	30-Aug
	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr
IV	600	ha palawija	10-Mar	10-May	01-Jun	01-Aug
	600	ha palawija	01-Jul	01-Sep	30-Sep	30-Nov
	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr
V	600	ha palawija	20-Mar	20-May	20-Jun	20-Aug
VI	600	ha paddy	10-Nov	10-Jan	28-Feb	30-Apr

By using this schedule it can be predicted the final time for planting in the next cropping season. Referring to above data, the value of effective rainfall for paddy and palawija can be calculated by using data of rainfall for paddy cropping pattern of paddy, paddy-palawija. The correlation is shown in Table 4.

Table 4 Correlation between rain fall and storage inflow (watershed area = 8912500 m^2) including effective rain

Month		**Rainfall (mm/10 days)**	**Planting coefficient (mm/10 days)**	
			paddy	**palawija**
	I	18,85		18,85
Nov	II	24,47		24,47
	III	31,02		31,02
	I	38,58		38,58
Dec	II	47,17		47,17
	III	56,86	45,49	56,86
	I	52,91	42,33	52,91
Jan	II	52,42	41,94	52,42
	III	51,43	41,14	51,43
	I	50,01	40,01	50,01
Feb	II	48,18		48,18
	III	46,01		46,01
	I	43,53		43,53
Mar	II	40,81		40,81
	III	37,88		37,88
	I	34,79		34,79
Apr	II	31,6		31,6
	III	28,35		28,35
	I	25,08		25,08
May	II	21,85		21,85
	III	18,7		18,7
	I	15,69		15,69
Jun	II	12,85		12,85
	III	10,24		10,24

(*cont.*)

Table 4 *(cont.)*

Month		Rainfall (mm/10 days)	Planting coefficient (mm/10 days)	
			paddy	palawija
	I	7,91		7,91
Jul	II	5,9		5,9
	III	4,26		4,26
	I	3,04		3,04
Aug	II	2,29		2,29
	III	2,05		2,05
	I	2,38		2,38
Sep	II	3,32		3,32
	III	4,92		4,92
	I	7,22		7,22
Oct	II	10,28		10,28
	III	14,14		14,14

The volume of water that is used especially for growth depending on evaporation rate and plant coefficient. Evaporation rate data is presented in Table 2, while plant coefficient are summarised in Table 5.

Table 5 Plant coefficient for paddy and palawija

Periods	Plant coefficient	
	Paddy	Palawija
10	0,92	0,35
20	1,04	0,46
30	1,16	0,61
40	1,24	0,71
50	1,28	0,77
60	1,29	0,73
70	1,24	0,71
80	1,11	0,61
90	0,90	0,47
100	0,00	0,00

3.3 Technical data of weir

Technical data of weir is summarised as follows:
Maximum weir storage: 1.251.360 m^3, with water surface area 832.597 m^2
Minimum weir storage: 350.m^3, with water surface area 4.070m^2 at elevation + 2,37
Area of river watershed: 8.912 m^2

4.0 CALCULATION TO BALANCE THE WEIR WATER

There are three main parameters which should be obtained before calculation proceed, namely the flow in the of stream, evaporation of water surface of weir storage and irrigation demand. Storage inflow is given in Table 1, which indicates that evaporation is very dependent on weir volume (per 1), which is also indicated by calculation process. For irrigation demand it is required to know surface area and water demand on each growth stage. The flowed area division is presented in Table 6.

Table 6 Paddy field area that is supplied for treatment and growth stage of paddy and palawija with total area 600 ha (all group)

Periods of 10 days	Paddy				Palawija
	Treatment for seeding ha	Land treatment ha	Seed growth ha	Plant growth ha	Plant growth ha
1	2,14	–	2,14	–	85,71
2	4,29	81,43	4,29	–	171,43
3	4,29	81,43	4,29	85,71	257,14
4	4,29	81,43	4,29	171,43	342,86
5	4,29	81,43	4,29	257,14	428,57
6	4,29	81,43	4,29	342,86	514,29
7	4,29	81,43	4,29	428,57	600,00
8	2,14	81,43	2,14	514,29	600,00
9	–	–	–	600,00	600,00
10	–	–	–	514,29	514,29
11	–	–	–	428,57	428,57
12	–	–	–	342,86	342,86
13	–	–	–	257,14	257,14
14	–	–	–	171,43	171,43
15	–	–	–	85,71	85,71
16	–	–	–	0,00	–
17	–	–	–	0,00	–
18	–	–	–		–

Water demand for land treatment has been given earlier, while for growth, it is dependent on both evaporation and plant coefficient. Special case for paddy where we need to consider the existence of percolation. Plant coefficient determination based on average coefficient of 7 groups by considering that plant start-up each group having 10 days difference. This is shown in Table 7.

Water Demand Unit represents the water needed for plant growth. It is considered as water for evapotranspiration determined by the water loss in paddy field and the

Table 7 Average plant coefficient for several types of cropping pattern

Month		pd, pd	pd	pl, pl	pl
Nov	I			0,60	
	II	0,92	0,92	0,54	
	III	0,98	0,98	0,47	
Dec	I	1,04	1,04		
	II	1,09	1,09		
	III	1,13	1,13		
Jan	I	1,16	1,16		
	II	1,17	1,17		
	III	1,19	1,19		
Feb	I	1,17	1,17		
	II	1,01	1,01		
	III	0,97	0,97		
Mar	I	0,91	0,91		
	II	0,83	0,81	0,35	
	III	0,79	0,67	0,41	0,35
Apr	I	0,80	0,45	0,47	0,41
	II	0,87		0,53	0,47
	III	1,13		0,58	0,53
May	I	1,16		0,61	0,58
	II	1,17		0,62	0,61
	III	1,19		0,66	0,62
Jun	I	1,17		0,66	0,66
	II	1,01		0,67	0,66
	III	0,97		0,66	0,67
Jul	I	0,91		0,57	0,66
	II	0,81		0,52	0,63
	III	0,67		0,50	0,60
Aug	I	0,45		0,52	0,54
	II			0,58	0,47
	III			0,61	

(*cont.*)

Table 7 (*cont.*)

Month		pd, pd	pd	pl, pl	pl
Sep	I			0,62	
	II			0,66	
	III			0,66	
Oct	I			0,67	
	II			0,66	
	III			0,63	

pd = paddy; pl = palawija

effective rainfall that prevails. Water Demand Unit is presented in Table 8 for paddy and Table 9 for palawija.

Water demand is water needed for land treatment and plant growth on a given paddy field area. By using other information we can estimate water demand for irrigation for palawija and paddy. (see Table 10 and 11)

Weir Water Balance is estimated by the following equation:

$$V\,(I) = V\,(I - 1) + 1\,(I) - E(I) - K(I)$$

On beginning November $i = 1$

$$V(I) \;= V(36) + I(1) - E(1) - K(1)$$

Definition:

If $V > 1.251.360\ \mathrm{m}^3$ then $V = 1.252.360\ \mathrm{m}^3$, and runoff exists
If $V < 350\ \mathrm{m}^3$ then lack of water exists.

Both definitions mentioned above do not exist in this paper, since if one or both definition exist, it means that water utilisation is not optimum.

V : weir volume
i : 1 i-nd periods , from 1 to 36
Nov I : $i = 1$
Oct III : $i = 36$
i : storage inflow
E : Evaporation of water surface which depends of height of elevation and surface area of water weir. Since surface area on dependent of weir volume (equation 1), hence correlation among *V*, *E* can be solved with iteration.
K : Irigation demand

Table 8 Calculation of water demand unit for irrigation for paddy crop growth

Month	Evapo-ration mm/day	Plant coeffi-cient	Evapo-trans-piration mm/dy	Perco lation mm/day	Water demand mm/day	Water loss mm/dy		Eff Rain mm/d	Demand Unit mm/day
I	7,00			2,00		5%			
Nov II	7,01	0,92	6,45	2,00	8,45	5%	0,44		8,8892
III	7,01	0,98	6,87	2,00	8,87	5%	0,47		9,3398
I	7,00	1,04	7,28	2,00	9,28	5%	0,49		9,7700
Dec II	6,99	1,09	7,62	2,00	9,62	5%	0,51		10,1291
III	6,96	1,13	7,86	2,00	9,86	5%	0,28	4,55	5,5948
I	6,81	1,16	7,90	2,00	9,90	5%	0,30	4,23	5,9696
Jan II	6,68	1,17	7,82	2,00	9,82	5%	0,29	4,19	5,9156
III	6,57	1,19	7,82	2,00	9,82	5%	0,44	4,11	6,1483
I	6,47	1,17	7,57	2,00	9,57	5%	0,43	4,00	5,9999
Feb II	6,40	1,01	6,46	2,00	8,46	5%	0,41		8,8740
III	6,33	0,97	6,14	2,00	8,14	5%	0,38		8,5201
I	6,28	0,91	5,71	2,00	7,71	5%	0,37		8,0848
Mar II	6,25	0,83	5,19	2,00	7,19	5%	0,37		7,5575
III	6,22	0,79	4,91	2,00	6,91	5%	0,39		7,3038
I	6,21	0,80	4,97	2,00	6,97	5%	0,47		7,4380
Apr II	6,21	0,87	5,40	2,00	7,40	5%	1,13		8,5327
III	6,22	1,13	7,03	2,00	9,03	5%	1,14		10,1686
I	6,23	1,16	7,23	3,00	10,23	10%	1,17		11,3968
May II	6,26	1,17	7,32	3,00	10,32	10%	1,16		11,4842
III	6,29	1,19	7,49	3,00	10,49	10%	1,05		11,5351
I	6,33	1,17	7,41	3,00	10,41	10%	1,02		11,4261
Jun II	6,37	1,01	6,43	3,00	9,43	10%	0,99		10,4237
III	6,41	0,97	6,22	3,00	9,22	10%	0,92		10,1377
I	6,46	0,91	5,88	3,00	8,88	10%	0,82		9,6986
Jul II	6,52	0,81	5,28	3,00	8,28	10%	0,66		8,9412
III	6,57	0,67	4,40	3,00	7,40	10%			7,4019
I	6,62	0,45	2,98	3,00	5,98	10%			5,9790
Aug II	6,68			3,00	3,00	10%			3,0000
III	6,73			3,00	3,00	10%			3,0000

Table 9 Calculation of water demand unit for irrigation for palawija crop growth

Month		Evaporation (mm/day)	Plant coefficient	Evapotranspiration (mm/day)	Water demnad mm/day	Water loss mm/day		Efective rainfall (mm/day)	Water demand unit (mm/day)
	I								
Jul	II	6,52	0,35	2,28	2,28	15%	0,34	0,59	2,03430
	III	6,57	0,41	2,69	2,69	15%	0,40	0,426	2,67176
	I	6,62	0,47	3,11	3,11	15%	0,47	0,304	3,27411
Aug	II	6,68	0,53	3,54	3,54	15%	0,53	0,229	3,84246
	III	6,73	0,58	3,90	3,90	15%	0,59	0,205	4,28391
	I	6,78	0,61	4,14	4,14	15%	0,62	0,238	4,51817
Sep	II	6,83	0,62	4,23	4,23	15%	0,64	0,332	4,53779
	III	6,87	0,66	4,53	4,53	15%	0,68	0,492	4,72233
	I	6,91	0,66	4,56	4,56	15%	0,68	0,722	4,52269
Oct	II	6,95	0,67	4,66	4,66	15%	0,70	1,028	4,32698
	III	6,98	0,66	4,61	4,61	15%	0,69	1,414	3,88382
	I	7,00	0,63	4,41	4,41	10%	0,44	1,885	2,96600
Nov	II	7,01	0,60	4,21	4,21	10%	0,42	2,447	2,17960
	III	7,01	0,54	3,79	3,79	10%	0,38	3,102	1,06194
	I	7,00	0,47	3,29	3,29	10%	0,33	3,858	
Dec	II	6,99		0,00	0,00	10%	0,00	4,717	
	III	6,96		0,00	0,00	10%	0,00	5,686	

Table 10 Distribution of irrigation demand volume for paddy (cropping pattern paddy, paddy, palawija)

Month	10-day periods	Water deman for (mm/day) Seed treat-ment	Land treat-ment	Seed growth	Area for (ha/day) Seed treat-ment	Land treat-ment	Seed growth	Water demand m^3/day	m^3/ 10 days	Water loss 15%	Total water demand (m^2/day)
	I	100	150								
Nov	II	100	150	8,8892	0,21		0,21	233	2330	349,5	2679,500
	III	100	150	9,3398	0,43	8,14	0,43	12683	126830	19024,5	145854,500
	I	100	150	9,77	0,43	8,14	8,57	13522	135220	20283	155503,000
Dec	II	100	150	10,129	0,43	8,14	17,14	14421	144210	21631,5	165841,500
	III	100	150	5,5948	0,43	8,14	25,71	14101	141010	21151,5	162161,500
	I	100	150	5,9696	0,43	8,14	34,29	14699	146990	22048,5	169038,500
Jan	II	100	150	5,9156	0,43	8,14	42,86	14699	146990	22048,5	169038,500
	III	100	150	6,1483	0,21	8,14	51,43	15195	151950	22792,5	174742,500
	I	100	150	5,9999			60,00	15543	155430	23314,5	178744,500
Feb	II	100	150	8,874			51,43	3538	35380	5307	40687,000
	III	100	150	8,5201			42,86	4575	45750	6862,5	52612,500
	I	100	150	8,0848			34,29	2781	27810	4171,5	31981,500
Mar	II	100	150	7,5575	0,21		25,71	2182	21820	3273	25093,000
	III	100	150	7,3038	0,43	8,14	17,14	13927	139270	20890,5	160160,500
	I	100	150	7,438	0,43	8,14	17,14	13937	139370	20905,5	160275,500
Apr	II	100	150	8,5327	0,43	8,14	17,14	14014	140140	21021	161161,000
	III	100	150	10,169	0,43	8,14	25,71	15123	151230	22684,5	173914,500

(cont.)

Table 10 *(cont.)*

	I	150	200	11,397	0,43	8,14	34,29	20863	208630	31294,5	239924,500
May	II	150	200	11,484	0,43	8,14	42,86	21884	218840	32826	251666,000
	III	150	200	11,535	0,21	8,14	51,43	22638	226380	33957	260337,000
	I	150	200	11,426			60,00	6952	69520	10428	79948,000
Jun	II	150	200	10,424			51,43	5384	53840	8076	61916,000
	III	150	200	10,138			42,86	4391	43910	6586,5	50496,500
	I	150	200	9,6986			34,29	3379	33790	5068,5	38858,500
Jul	II	150	200	8,9412			25,71	2370	23700	3555	27255,000
	III	150	200	7,4019			17,14	1410	14100	2115	16215,000
	I	150	200	5,979			8,57	570	5700	855	6555,000
Aug	II	150	200								
	III	150	200								

Table 11 Distribution of water irrigation demand for palawija (cropping pattern paddy, paddy, palawija)

Month	10-day periods	Water demand for growth (mm/ day)	Growth area	Water demand m^3/ day	Water demand m^3/ 10 days	Water Loss in passage	Total Water demand m^3/ 10 days
	I						
Jul	II	2,03430	8,57	174,3599	1743,599	261,540	2005,14
	III	2,67176	17,14	458,019	4580,19	687,028	5267,22
	I	3,27411	25,71	841,9046	8419,046	1262,857	9681,90
Aug	II	3,84246	34,29	1317,426	13174,26	1976,139	15150,40
	III	4,28391	42,86	1835,955	18359,55	2753,933	21113,49
	I	4,51817	51,43	2323,65	23236,5	3485,474	26721,97
Sep	II	4,53779	60,00	2722,674	27226,74	4084,011	31310,75
	III	4,72233	60,00	2833,398	28333,98	4250,097	32584,08
	I	4,52269	60,00	2713,614	27136,14	4070,421	31206,56
Oct	II	4,32698	51,43	2225,32	22253,2	3337,980	25591,18
	III	3,88382	42,86	1664,489	16644,89	2496,733	19141,62
	I	2,96600	34,29	1016,923	10169,23	1525,384	11694,61
Nov	II	2,17960	25,71	560,4623	5604,623	840,694	6445,32
	III	1,06194	17,14	182,0484	1820,484	273,073	2093,56
	I		8,57	0	0	0,000	0,00
Dec	II						
	III						

From above information, the data required to calculate water balance (Table 12) may be applied. Inflow is given in Table 1, height of evaporation from Table 2, irrigation demand obtained from summation of Table 10 and 11 in the same periods.

Based on Table 12 by employing Equation (2) the elevation of water surface in definite time is determined. By the same way, water balance for other cropping pattern can be calculated. Finally, all correlation between time and elevation of water surface for some cropping pattern are presented in Figure1.

Table 12 Calculation of weir water balance with cropping pattern paddy, paddy, palawija

Month		Inflow (m^3/10 days)	Weir water area (m^2)	Height of evaporation (m/10 days)	Volume of evaporation (m^3/10 days)	Irrigation demand (m^3/10 days)	Weir volume (m^3)	Elevation (m)
	I	67223	41275	0,07	2889,3	11694,61	94073,14	6,32
Nov	II	95203	79644	0,07	5575,1	9124,82	174576,24	7,44
	III	132318	68103	0,07	4767,2	147948,06	154178,98	7,18
	I	180883	76245	0,07	5337,2	155503,00	174221,83	7,37
Dec	II	243648	111138	0,07	7779,7	165841,50	244248,67	8,01
	III	323848	197547	0,07	13828,3	162161,50	392106,88	8,99
	I	279045	256520	0,07	17956,4	169038,50	484156,98	9,44
Jan	II	271250	306982	0,07	21488,7	169038,50	564879,74	9,75
	III	260160	346459	0,07	24252,1	174742,50	626045,11	9,95
	I	246344	477011	0,06	28620,7	178744,50	665023,95	10,50
Feb	II	230375	583574	0,06	35014,4	40687,00	819697,51	10,84
	III	212821	679058	0,06	40743,5	52612,50	939162,53	11,10
	I	194223	761558	0,06	45693,5	31981,50	1055710,55	11,30
Mar	II	175088	828613	0,06	49716,8	25093,00	1155988,77	11,44
	III	155879	789879	0,06	47392,7	160160,50	1104314,53	11,36
	I	137005	738515	0,06	44310,9	160275,50	1036733,13	11,24
Apr	II	118821	674161	0,06	40449,7	161161,00	953943,47	11,09
	III	101616	588975	0,06	35338,5	173914,50	846306,47	10,86
	I	85619	445551	0,06	26733,1	239924,50	665267,91	10,38
May	II	70998	294326	0,06	17659,6	251666,00	466940,35	9,67
	III	57859	150901	0,06	9054,1	260337,00	255408,29	8,53
	I	46259	125507	0,06	7530,4	79948,00	214188,87	8,22
Jun	II	36203	10685	0,06	641,1	61916,00	187834,77	7,94
	III	27661	90648	0,06	5438,9	50496,50	159560,39	7,66
	I	20577	78196	0,06	4691,8	38858,50	136587,13	7,41
Jul	II	14880	68525	0,07	4796,8	27255,00	119415,38	7,19
	III	10502	61095	0,07	4276,7	16215,00	109425,73	6,99
	I	7395	54966	0,07	3847,6	16236,90	96736,20	6,81
Aug	II	5551	48768	0,07	3413,8	15150,40	83723,04	6,60
	III	5021	40041	0,07	2802,9	21113,49	64827,69	6,27
	I	5941	29993	0,07	2099,5	26721,97	41947,21	5,78
Sep	II	8560	19829	0,07	1388,0	31310,75	17808,43	5,07
	III	13264	11826	0,07	827,8	32584,08	–2339,47	4,19
	I	20605	7538	0,07	527,7	31206,56	–13468,69	3,42
Oct	II	31341	9362	0,07	655,3	25591,18	–8374,21	3,79
	III	46460	19281	0,07	1349,7	19141,62	41434	5,02

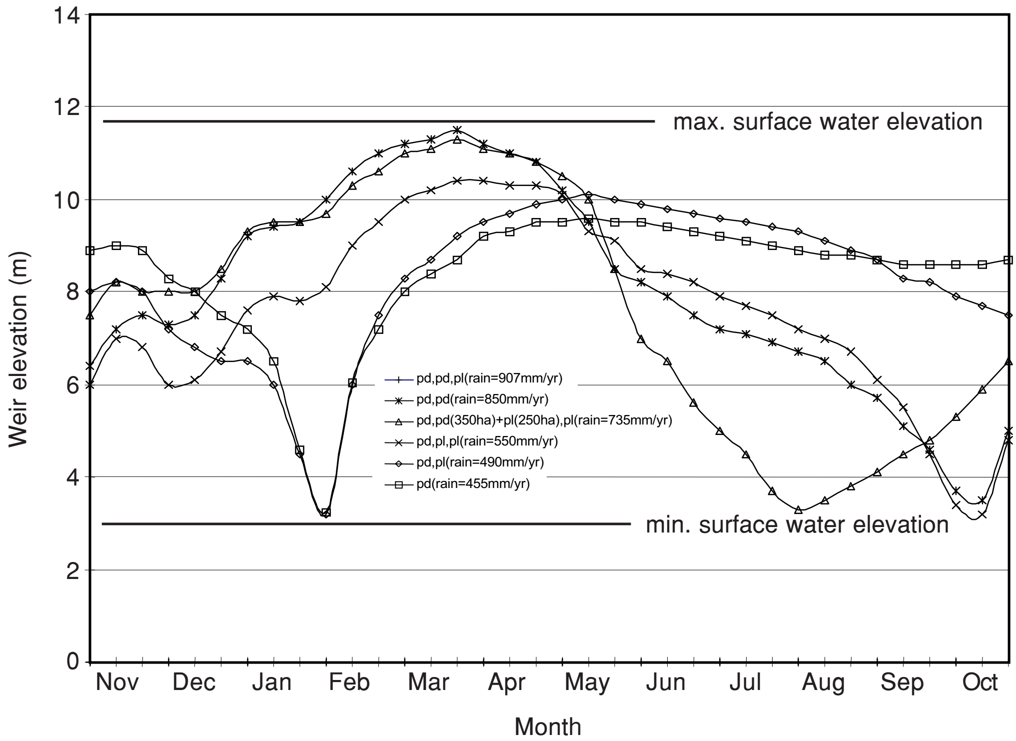

Figure 1 Monthly Variation of Water Elevation behind the Weir

5.0 DISCUSSIONS

The demand of irrigation water constitutes water volume taken from weir that is needed by plant for normal growth minus or plus rainwater volume that exists in irrigated area. Therefore, when rainfall is high, the demand of irrigation water is low, even though weir volume is larger. In order to prevent such case, there is a need for additional irrigated area or changing cropping pattern. Conversely, when rainfall is low, irrigation demand is high, and weir volume is low. This makes the weir to become dry. In order to prevent this case, the approach is either field paddy area reduction or changing cropping pattern. It can be concluded that cropping pattern is very dependent of rainfall, so that once rainfall is given, the cropping pattern can be determined. Althought it is difficult to determine rainfall intensity in the upcoming period, the problem may be addressed employing the irrigated area with suitable cropping pattern. The rainfall used is annual rainfall which is distributed in ten-days rainfall at a given percentage. In case of irrigation of the weir, first plant in cropping pattern is paddy, the second is paddy or 350 m^2 paddy and palawija 250 m^2 ha or palawija or "bero" (no planted). The third plant is palawija or "bero". During first plant, elevation of water surface are recorded and then plotted in Figure 1. The closest cropping pattern becomes the applied cropping pattern. It is better to employ water surface elevation in first plant to determine the second plant, whereas such elevation on the first and second plant employed can be used to determine the third plant.

In order to understand more about rainfall that occurs, calculation of water balance will be more focused when first plant proceeds, that is from November until February by using minimum rainfall via trial several variation of water surface elevation of initial plant so that applied rainfall can be suppressed at minimum. (See Figure 2).

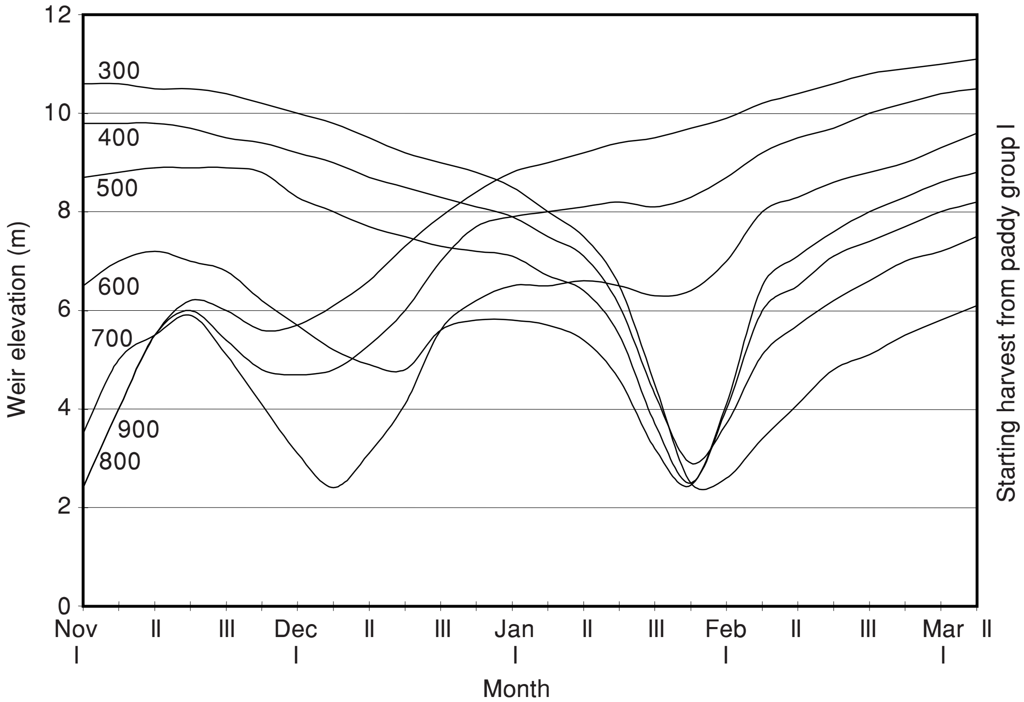

Figure 2 Correlation between water surface elevation vs time for paddy against several minimum rainfall based on variation of initial elevation

From Figure 2, it can be noted that when water surface elevation in the initial plant of first paddy approaches + 11 m, and elevation drops until end of January, so it is not recommended for the next plant. If the rainfall is 455 mm/year, the cropping pattern is paddy only (see Figure 1). When water surface elevation in initial plant period is 2.37 m, then rises sharply so we have rainfall of + 800 mm/ys. It means that paddy is acceptable.

When water surface elevation in the initial of November is higher than in the end of February, it is better to plant palawija (not paddy). From water surface elevation plotting (see Figure 2) the suitable rainfall can be predicted. According to figure 1, paddy may be chosen as next plant only when rainfall is 850 mm/year. Frequently, it is difficult to determine the rainfall because it is impossible to fit with the graphic, but only determined by observing the up and down of elevation. For rainfall less than 700 mm/year, then rainfall drops slightly or even rises. This may be used to determine the water surface elevation, so that the next plant is paddy.

When the calculation of water balance is focused on paddy as a species for second planting season, by manipulating water surface elevation on initial planting season, then correlation between water surface elevation against time for several rainfall can be seen in Figure 3. According to Figure 1, paddy as species of second planting season is recommended if rainfall is 600 mm/year because it can fulfill irrigation demand by one restriction in which the elevation is 11 m on the initial planting season (March).

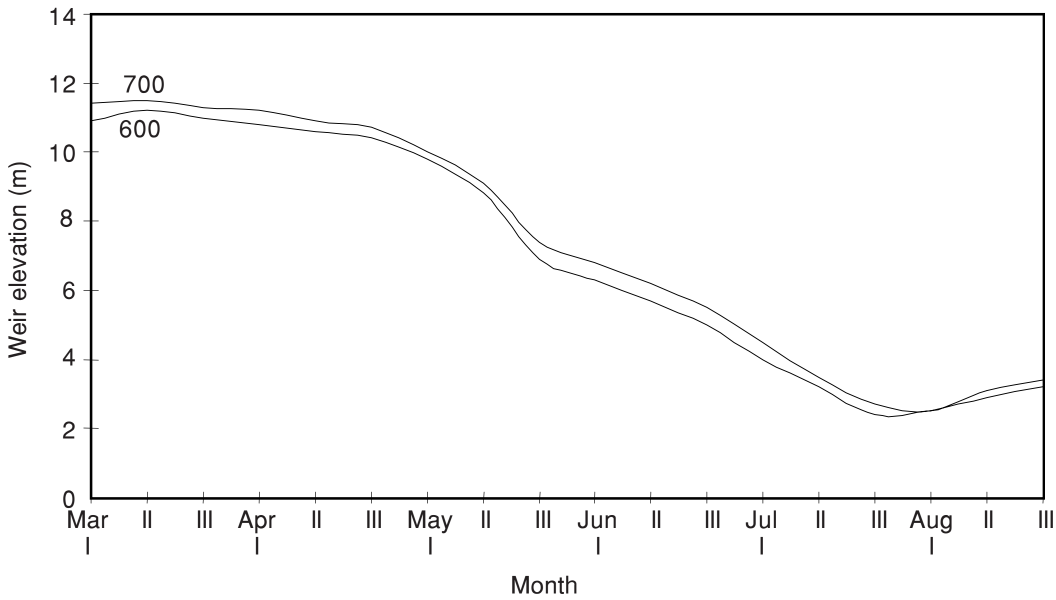

Figure 3 Correlation between water level elevation of weir vs. time for cropping pattern during second plant season of several rainfall

If it is not possible to plant paddy in the whole area during second planting season, the paddy can be partially planted and the other for palawija. Figure 4 is the results of calculation of weir water balance for paddy 350 m^2 and palawija 250 ha. It can be seen that eventhough rainfall is low but water elevation is sufficiently high, so that water weir is capable of supplying the irrigation.

When palawija is recommended as a crop for second cropping seasons, then according to calculation of water balance which focuses only to palawija, the rainfall 275 mm/ys is capable for irrigation. (Figure 5). This rainfall is impossible, but generally

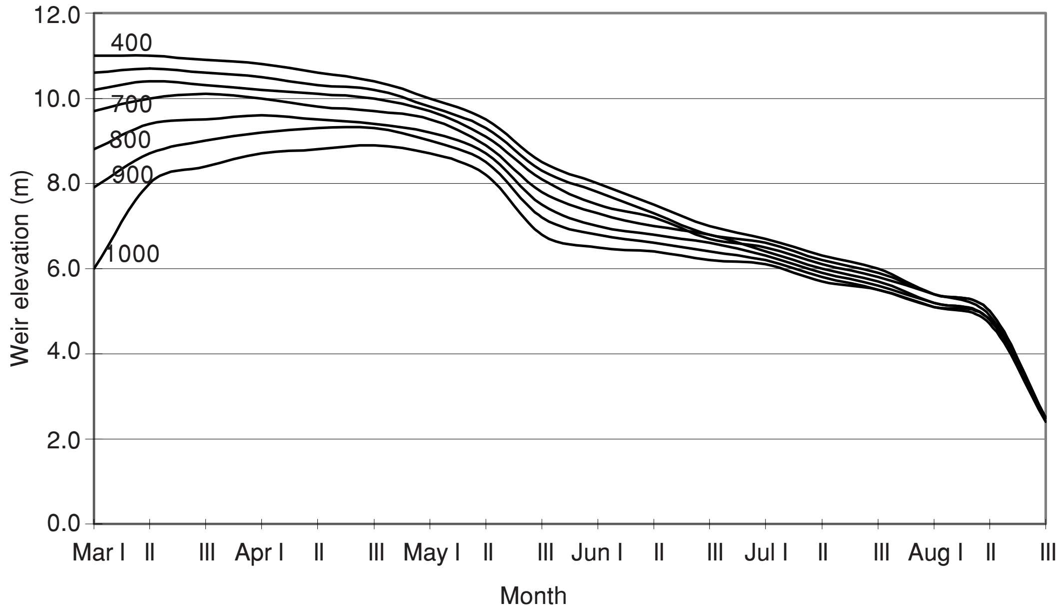

Figure 4 Correlation between water elevation vs. time for cropping pattern paddy (350 ha) and palawija (250 ha) with several rainfall.

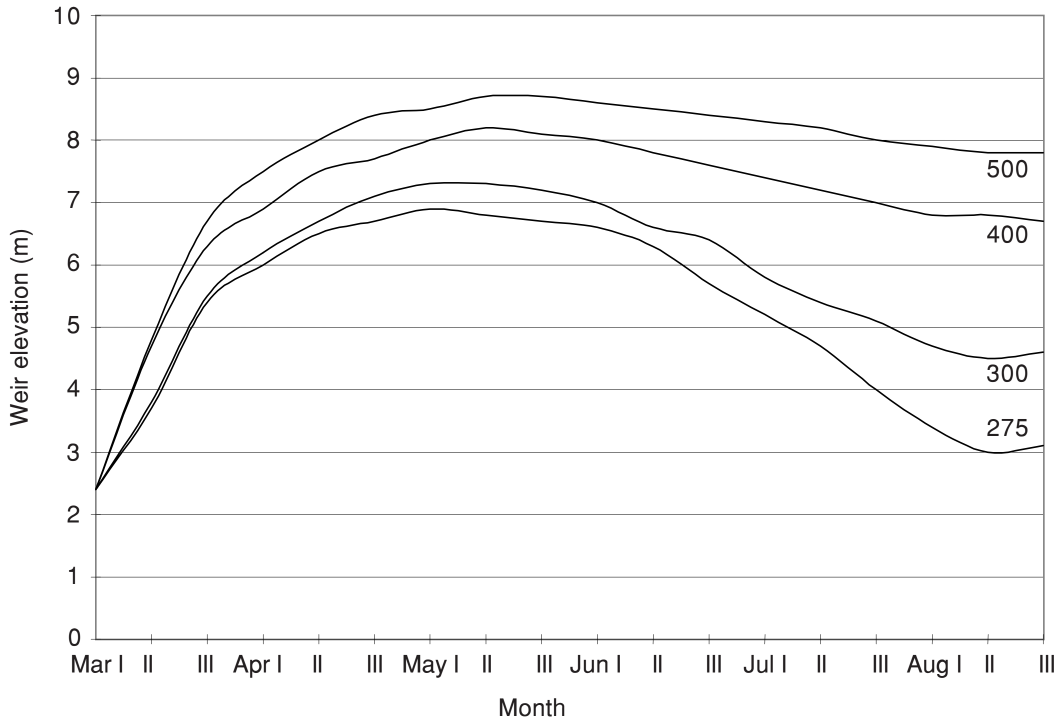

Figure 5 Correlation between water surface elevation vs. time for palawija cropping pattern on second planting seasons of several rainfall

500 mm/year can be achieved. For this reason palawija is recommended as cultivan for second planting season without evaluating elevation data.

In the third planting season when palawija can be planted, correlation between water surface elevation vs. time on third planting seasons of several rainfall is presented in Figure 6.

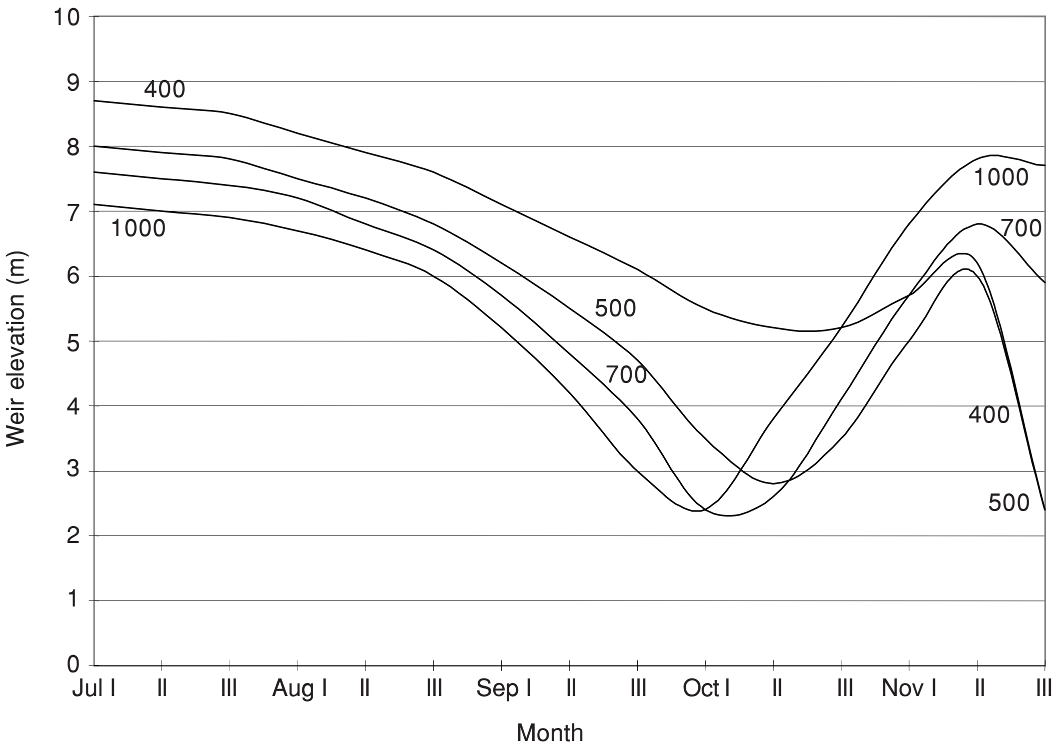

Figure 6 Correlation between water surface elevations vs. time for palawija 500 cropping pattern on third planting seasons of several rainfall

The month of July is dry season so that weir function is significant. From Figure 6, eventhough the rainfall is 1000 mm/year, when elevation on initial planting season very low (less than + 7m), therefore the end of September drought may happen, but starting from October it will rise drastically, so then paddy is acceptable in November. In case when the rain fall is 400-500 mm/year, the initial elevation (July) is high.

6.0 CONCLUSION

The procedure for predicting cropping pattern based on water surface elevation of weir can be carried out as follows:

- Preparing graphic that correlates between water surface elevation to variation of cropping pattern
- Since the weir is operated, recording of water surface elevation, species of plant and area of land farm should be done.
- The water surface elevation is plotted so that evaluation carried out by comparing real elevation and calculation result.
- Cropping pattern can be determined by evaluation result.

For higher water surface elevation behind the weir, the more accurate species of plant can be recommended.

In order to have more description about water surface elevation, calculation of water balance must be focused on each plant species from the planting to harvesting by using combination of some variation between rainfall and elevation of water surface in the initial year.

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