THE CONTRIBUTION OF RICE FARMING ON NITROGEN ENRICHMENT IN *YEH SUNGI* WATERSHED, TABANAN BALI

I Wayan Alit Artha Wiguna[1), J. Stephen Lansing[2) and Oka Adnyana[3)

[1) Balai Pengkajian Teknologi Pertanian Bali, Jl. By Pass Ngurah Rai PO Box 3480, Denpasar
[2) Departemen Anthropology Univ. of Arixona
Emil Haury Building, RM 225, PO Box 210030, 1009 E. South Campus Dr. Tucson, AZ 85721-0030
[3) Pusat Penelitian dan Pengembangan Sosial Ekonomi Pertanian, Jl. A. Yani 70 Bogor 16161

ABSTRAK

Pelaksanaan program intensifikasi pertanian melalui konsep revolusi hijau membuat meningkatnya produksi padi secara dramatis sehingga pada tahun 1984 Indonesia mencapai swa-sembada beras. Uniknya, sebelum tahun 1984 Indonesia dikenal sebagai negara pengimpor beras yang terbesar di dunia. Akan tetapi, disamping prestasi yang spektakular dalam produksi padi, dalam beberapa hal revolusi hijau juga memberi kontribusi dampak yang tidak menguntungkan terhadap ekosistem.Perkembangan pertanian di Bali, khususnya sawah sangat terkait dengan sistem subak. Subak adalah pengaturan air irigasi tradisional di Bali yang telah dilaksanakan sejak berabad-abad yang lalu. Sehubungan dengan masalah di atas, penelitian ini telah dilaksanakan di Daerah Aliran Sungai (DAS) Yeh Sungi di Kabupaten Tabanan, daerah di bagian barat Bali. Daerah penelitian meliputi delapan subak yaitu: Subak Apit Yeh and Subak Uma Poh di daerah hulu tempat tangkapan air; Subak Padangakitan, Jaka, Sungi I, Bena, dan Subak Tangkub di daerah tengah; dan Subak Gde Gadon I di daerah hilir. Penelitian ini dilakukan selama 12 bulan, mulai dari bulan April 2001 hingga Maret 2002. Tujuan penelitian adalah: (1) meneliti tingkat pengayaan hara nitrogen di air irigasi yang berkaitan dengan aplikasi intensif pupuk anorganik di berbagai sistem pertanian dalam sistem subak di Bali; (2) meneliti kualitas lingkungan air, berkaitan dengan tingkat pengayaan hara nitrogen di dalam air irigasi. Hasil penelitian menunjukkan bahwa pengayaan hara pada air irigasi berkaitan dengan sistem pertanian pada sistem subak. Tingkat pengayaan hara di daerah hulu lebih tinggi daripada di daerah tengah dan hilir untuk N-NO3-; untuk memelihara kelangsungan ekosistem Subak, maka aplikasi pupuk N harus mempertimbangkan kandungan hara tersebut dalam air irigasinya. Pelaksanaan pertanian telah menyebabkan pengayaan hara nitrogen yang berlebihan di daerah irigasi, khususnya di daerah tengah maupun hilir yang masing-masing didominasi oleh pola pertanian padi-padi-padi dan padi-padi-palawija. Untuk memelihara kelangsungan ekosistem subak, maka aplikasi pupuk nitrogen harus mempertimbangkan kandungan hara di air irigasi.

Kata kunci*: sistem pertanian padi, pengayaan air irigasi, ekosistem subak.*

ABSTRACT

The implementation of agricultural intensification program through the green revolution concept has made the increasing rice production dramatically and in 1984 Indonesia achieved ice self-sufficiency. Uniquely, before 1984 Indonesia was known as the biggest rice importing country in the world. However, beside of spectacular achievement in rice production, green revolution to some cases also contributes less favorable impact to the ecosystem. The agricultural development in Bali, particularly rice field is closely related to the subak system. Subak is a traditional model of irrigation water treatment in Bali practiced since centuries ago. The related to above-mentioned issues, this research has been conducted at Yeh Sungi watershed in Tabanan District, western part of Bali. The research site includes eight subaks: Subak Apit Yeh and Subak Uma Poh at upstream area of catchments area; Subak Padangakitan, Jaka, Sungi I, Bena, and Subak Tangkub at the middle area; and Subak Gde Gadon I at downstream area. This research was carried out for 12 months between April 2001 and March 2002. The objection of this research were: (1) to investigate the water enrichment level of N nutrients in the irrigation water related to the intensive application of inorganic fertilizers at various farming systems in subak system in Bali; (2) to investigate the water environment quality, related to the water enrichment level of N nutrient in the irrigation water. Research results showed that nutrient enrichment on irrigation water related to farming system on subak ecosystem. The level of nutrient enrichment at upstream (hulu) area is higher than the middle (tengah) and downstream (hilir) areas for N-NO_3^{-}. To maintain the sustainability of subak ecosystem, therefore the application of N fertilizer should consider those nutrients content in irrigation water. The agricultural practice has caused excessive enrichment of N nutrients in irrigated area, especially at the middle as well as downstream areas dominated by rice-rice-rice and rice-rice-palawija (second crop) cropping patterns.

Key words: *rice farming system, water enrichment, subak ecosystem.*

INTRODUCTION

The implementation of agricultural intensification program is inseparable with the role of agriculture horticulture technology, such as: (1) fertilizer management; (2) land management; (3) plant-pest controlling; (4) qualified seed utilization; (5) harvesting and post-harvesting management (Sugianto, 2000). More than three decades, Indonesian farmer society has used intensive inorganic fertilizers and pesticide in farming system development which cause environment pollution. Pollution in nitrogen (N) nutrient generally derived from urea and ZA fertilizers. The nutrient pollution happens through surface flow, under surface flow, ground water, soil sediment, volatilization, and farm wastes, such as stubbles, dried-bean stalks, and plant residues (Gilliam *et al*., 1997; Ongle 1996). Nitrogen reduction through surface flow easily happens in seasonal-crops land, but many influential factors make great ranges. Furthermore, Reddy *et al* (1995) stated that surface flows in agricultural region is a non point resource of the phosphorus and gives obvious contribution to P in aquatic system. Application of inorganic fertilizer in modern agriculture has been known to be one of cause of enrichment level of N nutrient in the waters. Enrichment in the nutrient has given benefit as well as loss to the farmer due to pollution in waters resources. The main factor estimated as cause of enrichment level of N nutrient in the waters was urea fertilizer utilization (Wilbur 2000). Intensification of the fertilizer has caused change of traditional farming system into modern one that is farming system, which promoted production and productivity aspect using various technology inputs (Pitana, 1997). The modern farming system in agriculture development program is created in the form of agricultural intensification program since about 1967, in which has mistaken in its implementation, because do not take waters environment conservation aspect into account. So this condition mean, that the farmers in subak ecosystem was implemented the unsustainable agricultural technologies more than last 20 years. Efforts of pursuing the concept of sustainable agriculture development in subak system can be realized, if the above issues can be minimized. So the research about "Rice Farming System Contribution to the Enrichment of Nitrogen Nutrient Through Surface Run-Off at Subak Ecosystem in Bali" is very importance.

The objectives of this research is to formulate: (1) level of enrichment of N nutrient in the waters related to inorganic fertilizer utilization to the various farming system in subak ecosystem; (2) rationalization in N fertilizer utility as one of modern agriculture technology concept to subak system through 3R concept (*Reused, Recycling,* and *Reduced*). The implementation of the results of this research will be useful to reduce enrichment level of N nutrient is surface run-off, therefore it create sustainability rice farming system and conservation of subak ecosystem. In addition, this research's results are also beneficial for agriculture application especially in rational urea fertilizer utilization, which is turn, is able to reduce fertilizer utilization and rice farming system costs.

METHODOLOGY

This research was conducted in the subaks of Yeh Sungi Watershed regions at Tabanan, Bali. The research comprises eight subaks i.e. : Subak Apit Yeh and Uma Poh in the upstream, Subak Padangakitan, Jaka, Sungi I, Bena, and Tungkub in the middle area, and Subak Gde Gadon I in the downstream. Purposively the subak chosen was based on: (1) the location of the subak was in Yeh Sungi watershed (Figure 1); (2) irrigation water originated from the Spring of Yeh Sungi watershed; (3) the farmers in that subak system applied nitrogen fertilizer at least for the last 20 years. The research was carried out for 12 months, between April 2001 and March 2002. Two approaches carried out in this research were:

1. Model I: Research in irrigation water in rice field region, Yeh Sungi Watershed

Water samples were carried out in water flow points: (1) water flow from irrigation channel to the first division of rice field (inflow); (2) water flow from the 1st division of rice field to the 2nd division of rice field (water flow-1); (3) water flow from the 2nd division of rice field to the 3rd division of rice field (water flow-2); and (4) water flow from the 3rd division of rice field to the 4th division of rice field or directly flow to irrigation channel (outflow) (Figure 2). The number of samples taken from each station was 8–10 samples; totaled of 482 samples that was analyzed. There were 14 water sample point stations involving 14 farmers, among others 4 stations in upstream watershed, 6 stations in the middle watershed, and 4 stations in downstream watershed. Nitrate ($N\text{-}NO_3^-$) concentration in the water irrigation was supervised as a parameter in this research. Two goals of this research model there are: (1) finding the enrichment level of N nutrient from inflow of rice field area into the outflow of the rice field area; (2) relationship between enrichment of N nutrient in rice field area and farming system that was carried out by the farmer.

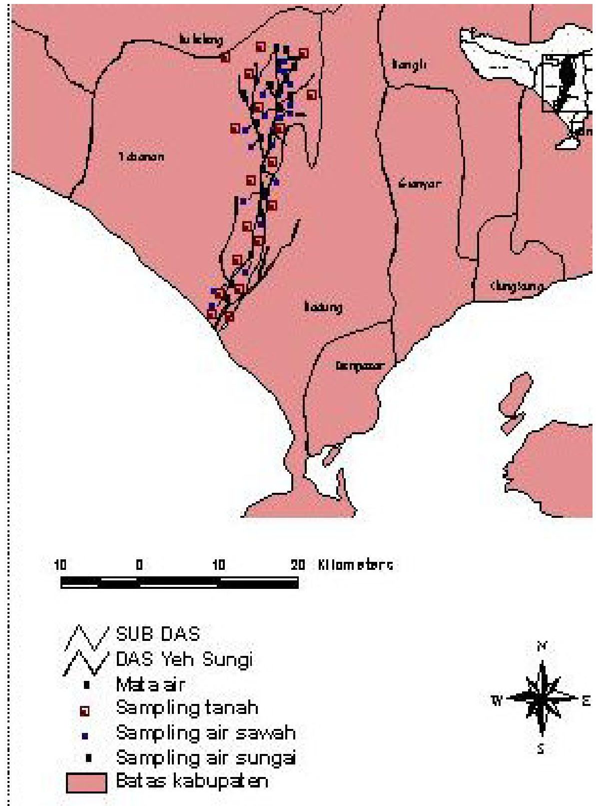


Figure 1. The Research Area of Yeh Sungi Watershed at District of Tabanan, Bali

2. Model 2: Research in river flow and spring, Yeh Sungi Watershed region

The research was carried out in water of the river in Yeh Sungi watershed from upstream into downstream, and in some water resources (springs) flow and become sub-watershed of Yeh Sungi. There were 18 sample point stations, namely (1) four springs in the upstream of watershed, (2) two springs in the middle of watershed, (3) three stations in the upstream of watershed, (4) six stations in the upstream of watershed, and (5) three stations in the downstream of watershed. The sample was taken once in a month in the same time and the same sampling station. Nine samples were collected from each station, totaled to 126 samples from 18 stations. The concentration of nitrogen nitrate ($N\text{-}NO_3^-$) as a parameter to supervise in each water sampling point stations. Sampling analyses in the watershed and spring water were aimed at finding enrichment level of N nutrient in the upstream to the downstream of watershed, including that in the springs. $N\text{-}NO_3^-$ concentration was measured on the site by using Colorimeter of DR/890 type, made in Hach Company (1997). The measurement was carried out with duplo method and used the clean plastic bottles as sampling water containers. To know the nitrogen enrichment of the irrigation water in the rice field and in the river waters of Yeh Sungi watershed region, so the N concentration concerned was compared by Class 2 water quality standard of the Government Regulation (PP) No. 82 year 2001 (Bappedal 2002). Subsequently, to find out enrichment level of N nutrient, the calculation was based on the difference of nutrient concentration between inflow and outflow of rice field water, and differences of that between upstream and the middle, and the differences of that of between the middle and watershed waters. To find difference level between various variables caused by farming system differences in watershed region, multivariate analyses were carried out in this research (Vincent 1992).

RESULT AND DISCUSSION

Characteristic of the Research Region and Farmers

Yeh Sungi watershed flows about 50 km long, started from Tamantanda village, sub district Baturiti in the upstream until Beraban village, sub district Kediri in the downstream, irrigated about 3,850 ha of rice field. Irrigation in rice field in watershed region was regulated by six *empelan* (semi-permanent dams) in the upstream watershed to irrigated 2,688 ha of rice field, and three dams in the downstream of watershed, irrigated 951 ha of rice field. Yeh Sungi watershed irrigated rice field in the middle for 70 percent from total of rice field, which was wider than that of the upstream (5%) and downstream (25%). Most of upstream of Yeh Sungi watershed was in the altitude of 600 and 1,200 meter above sea level. Yeh Sungi watershed has almost complete ecosystem model in the view of watershed topography. The watershed has a dozen of sub-watersheds, and flows water from upland to lowland. Some various conditions of the regions in Yeh Sungi watershed have caused differences in farming system. In the dry land located in the upstream of watershed generally is the region with dry land farming mainly planted with vegetables cultivated annually.

Farming system patterns in the upstream are dominated with rice-vegetables-vegetables with 95 percent of local rice crops. In the middle is undertaken by the pattern of rice-rice-rice of new varieties (100%). In the downstream, however, the farmers dominantly plant rice-rice-palawija (secondary crop) with new varieties of rice (100%). All the farmers in the middle and downstream plant new variety of rice, practiced since more than 20 years ago. There are six reasons why the farmers plant the new varieties of rice: (1) the rice productivities are high; (2) the harvest periods are short, (3) it is easy to cultivate, manage the harvest and post-harvest, (4) the crops are strong enough, (5) they have recommendation from the government and direction by their subak head (pekaseh), and (6) they follow the regulation (awig-awig) of subak. The topography of the upstream watershed is hilly with the slope of 15–45^o, and there are some springs flowing water to sub-watersheds of Yeh Sungi. The condition has caused division of rice field with perfect terraces. Irrigation water is available for all year long, and often springs are found in the upstream of the rice field, and directly can be used as irrigation water sources. Irrigation water almost has no problem for the farmers in Yeh Sungi watershed.

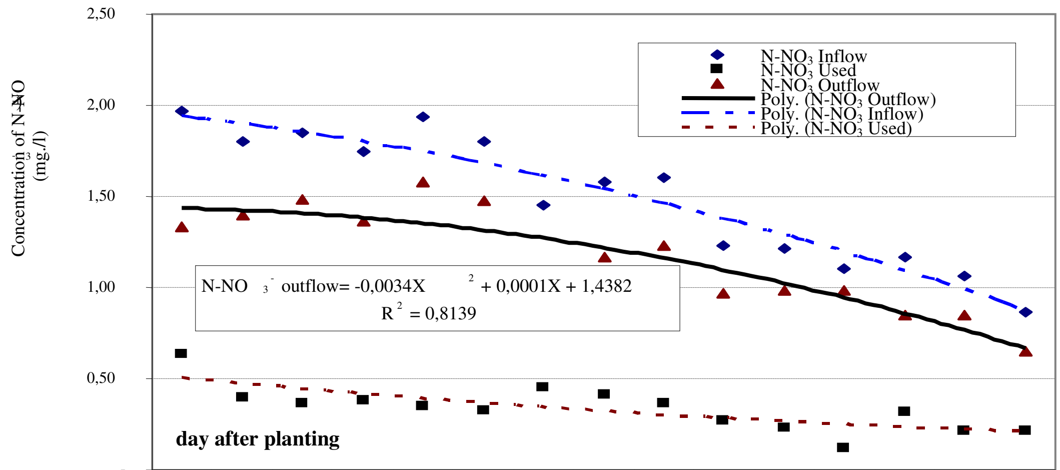
Yeh Sungi watershed in the middle is located in the height of 200 and 600 meters above sea level. The topography of the middle in Yeh Sungi watershed generally is hilly with slope of of 8-15^o. Irrigation system is good, because it is supported by eight dams which functioned to regulate irrigated water flow. In some places in the middle of Yeh Sungi watershed there are some springs. This is one of the reasons why the farmers plant new variety of rice as their min crop with rice-rice-rice cropping pattern. Regarding fertilizer usage for rice field farming system, the farmer in downstream of Yeh Sungi watershed used 325.28 kg. The fertilizer usage is significantly high (P=0.05) if compared to the farmers in the upstream watershed who applied urea fertilizer of 43.00 kg/ha. Whereas the farmers in the middle of watershed used 311.39 kg/ha. The result of the research was in conformity with that of Surdianto (1999) who stated that generally the farmers used urea fertilizer between 150 and 250 kg/ha on rice field, and they increased the dosage if they thought that the application rates were low or after pests and diseases attack. Imbalance application of fertilizer will aggravate the soil condition and possibility of pests and diseases attack (Yadav *et al.*, 1997).

In using organic fertilizer, the farmers in upstream of watershed use the fertilizers better than those in the middle and downstream. The farmers in the upstream of watershed applied 3,400 kg/ha of organic fertilizer, and significantly high (P=0.05) if compared by the middle and downstream with usage of 1,344 and 551 kg/ha, respectively. In view of environment conservation, the usage of stubbles as *mulsa* is a wise conduct because the farmers directly or indirectly have implemented 3R concept (*Reused*, *Recycling, and Reduced*). *Reused* in this case means the farmer utilizes the nutrient in the stubbles as one of nutrient resources for the plants. *Recycling* means that the nutrient in the stubbles will be returned into the rice field and makes the rice field to receive the nutrient that may be lost if the stubbles or paddy straw was expelled from rice field or to be burned. *Reduced* in this case is decrease in pollution if the stubbles are expelled anywhere or to be burned. Because, if it is expelled into irrigation channel, for instance, it can block water flow and also, if the stubbles were burned, it can cause air pollution because of CO_2 as burning product.

Utilization of stubbles as *mulsa* or organic fertilizer can reduce air pollution concerned. In the middle and downstream of watershed, 80 farmers of the farmers burn the paddy straw after harvesting with the reason of facilitating land management and destroy the diseases or pest in the stubbles so that it cannot be contagious. Some reason why the farmers in the middle and downstream do not use organic fertilizers in their farming system among others are: (1) they have difficulty to find the fertilizer in the market; (2) they need high volume of the fertilizer and it means high cost; (3) they have not yet received recommendation from the government. This shows that the farmers in the middle and downstream heavily depend on inorganic fertilizers to secure its farming system. This condition was caused by farmers' habit who have applied inorganic fertilizers for a long period of time. Inorganic fertilizers have given quick responses in farming system and in turn the farmers leave organic fertilizer usage.

Nutrients Concentration in Rice Field Water in Yeh Sungi Watershed

In general, $N\text{-}NO_3^-$ nutrient concentration increases from upstream to downstream. This condition has tight relations with fertilizer in each watershed division region. The concentration of $N\text{-}NO_3^-$ (mg/l) in the inflow water on rice field is always higher than that of

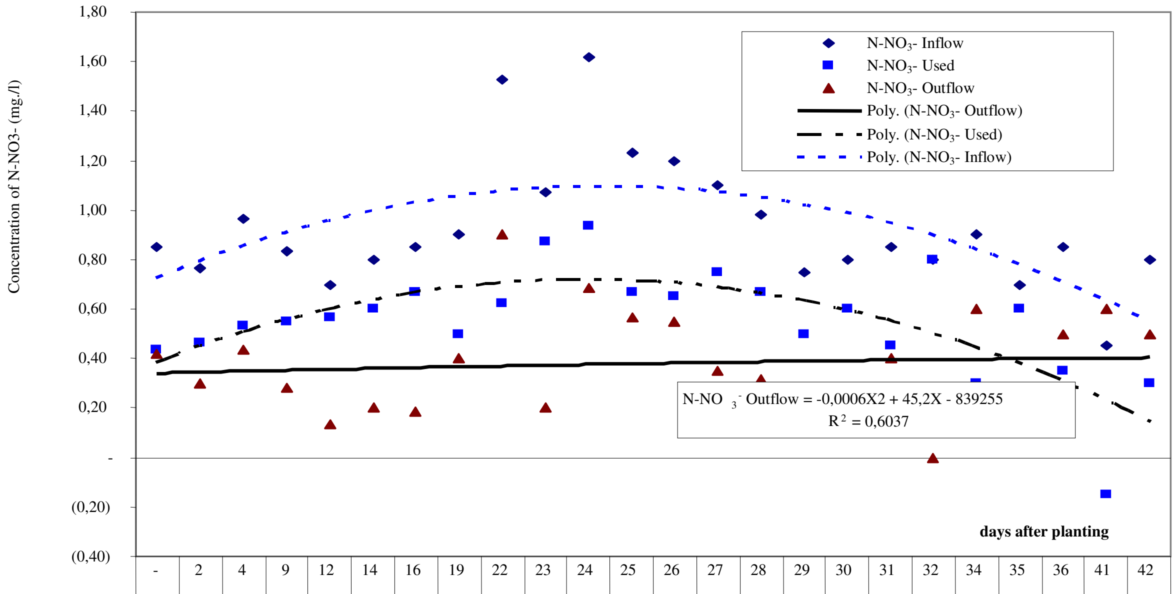


	14	16	18	19	22	26	29	33	39	44	47	51	54	61	68
N-NO3 Inflow	1,97	1,80	1,85	1,75	1,93	1,80	1,45	1,58	1,60	1,23	1,22	1,10	1,16	1,07	0,87
N-NO3 Used	0,63	0,40	0,37	0,38	0,35	0,33	0,45	0,42	0,37	0,27	0,23	0,12	0,32	0,22	0,22
N-NO3 Outflow	1,33	1,40	1,48	1,37	1,58	1,48	1,00	1,17	1,23	0,97	0,98	0,98	0,85	0,85	0,65

Figure 2. Nitrogen-nitrate ($N\text{-}NO_3^-$) Concentration in Water Irrigation at Upstream of Yeh Sungi Watershed in Tabanan, Bali, 2001/2002

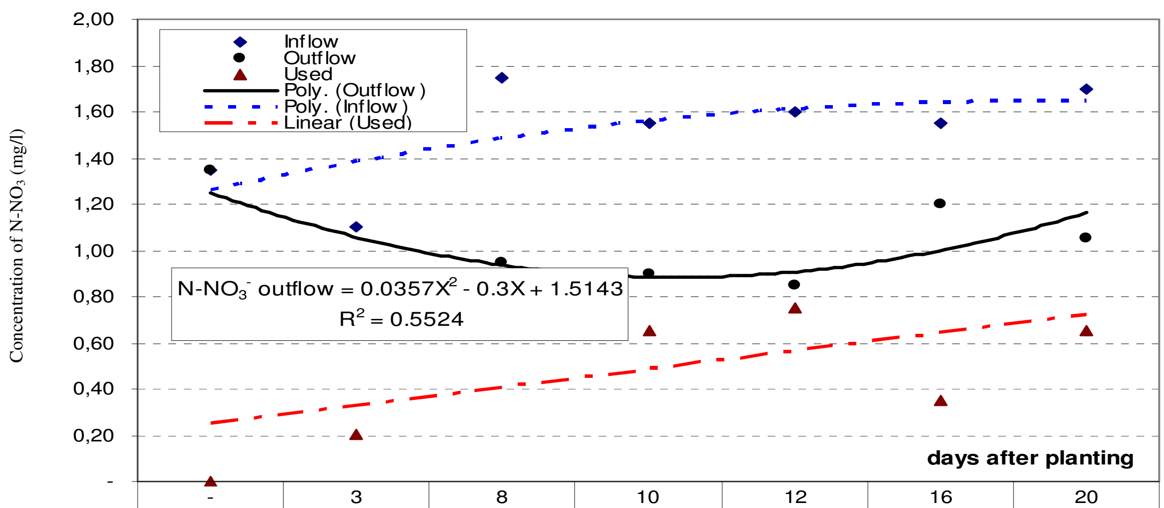
in outflow, in line with increase of rice crop age (in days) (Figure 2). This condition has proved that $N\text{-}NO_3^-$ nutrients in irrigation waters can be utilized by rice plants during growth process thus decreasing total of $N\text{-}NO_3^-$ nutrient expelled into surface run-off. This model showed that $N\text{-}NO_3^-$ nutrient in irrigated water in the upstream can be reused as N nutrient source for rice plant in the downstream. This is an implementation of one of 3R concept, i.e. *reused* in environmental management wisely and this can reduce the N nutrient concentration in the water, thus reducing pollution level of N nutrient in surface run-off. There was difference in change patterns of $N\text{-}NO_3^-$ concentration between rice field water in the middle and downstream. $N\text{-}NO_3^-$ concentration of rice field water in outflow channel in the middle tended to increase in line with increase of the age of rice plant (days), even in outflow channel tended to be higher than that of inflow channel (Figure 3).

In the downstream, however, $N\text{-}NO_3^-$ concentration in outflow channel since the time of planting was tending to $N\text{-}NO_3^-$ reach concentration in the inflow channel. This has proved that rice plant in the middle was more effective in utilizing $N\text{-}NO_3^-$ of irrigation water as N source for the growth, if compared by the plant in the downstream was less utilize $N\text{-}NO_3^-$ that has source from irrigated water, since beginning of planting until the age of 45 days. $N\text{-}NO_3^-$ in rice field water in the downstream decrease in line with $N\text{-}NO_3^-$ nutrient in irrigation water in inflow channel. This condition showed that $N\text{-}NO_3^-$ nutrient in irrigation water in the downstream was less utilized by rice plant, thus it was expelled in to the water. Therefore, the farming system pattern in the downstream was also potential in causing $N\text{-}NO_3^-$ nutrient catchment in the water and increased $N\text{-}NO_3^-$ concentration in outflow channel of division of rice fields. It also originated from fertilizer utilized by the plants and was expelled into surface run-off. That condition had opportunity of euthrofication in estuary, which could cause damage in water and land ecosystem.



	-	2	4	9	12	14	16	19	22	23	24	25	26	27	28	29	30	31	32	34	35	36	41	42
◆ N-NO3- Inflow	0,85	0,77	0,97	0,83	0,70	0,80	0,85	0,90	1,53	1,08	1,62	1,23	1,20	1,10	0,98	0,75	0,80	0,85	0,80	0,90	0,70	0,85	0,45	0,80
■ N-NO3- Used	0,43	0,47	0,53	0,55	0,57	0,60	0,67	0,50	0,63	0,88	0,93	0,67	0,65	0,75	0,67	0,50	0,60	0,45	0,80	0,30	0,60	0,35	(0,1	0,30
▲ N-NO3- Outflow	0,42	0,30	0,43	0,28	0,13	0,20	0,18	0,40	0,90	0,20	0,68	0,57	0,55	0,35	0,32	0,25	0,20	0,40	-	0,60	0,10	0,50	0,60	0,50

Figure 3. Nitrogen-nitrate ($N\text{-}NO_3^-$) Concentration in Water Irrigation at Middle of Yeh Sungi Watershed in Tabanan, Bali, 2001/2002



	-	3	8	10	12	16	20
◆ Inflow	1,35	1,10	1,75	1,55	1,60	1,55	1,70
● Outflow	1,35	0,90	0,95	0,90	0,85	1,20	1,05
▲ Used	-	0,20	0,80	0,65	0,75	0,35	0,65

Figure 4. Nitrogen-nitrate ($N\text{-}NO_3^-$) Concentration in Water Irrigation at Downstream of Yeh Sungi Watershed in Tabanan, Bali, 2001/2002

Nitrogen Enrichment in the Water of the Springs and the Rivers

N-NO_3^- concentration (mg/l) of river water in the upstream (2.259 mg/l) was significantly higher (α =0.05) than that in the middle (1.490 mg/l) and downstream (1.182 mg/l). In this case, nitrate nutrient in river water decreases significantly from the upstream to downstream (Table 1). Table 1 also shows that nitrate nutrient in the springs was significantly higher (α=0.05) than that of nitrate nutrients in river water. Subsequently, Table 1 shows that enrichment level of N-NO_3^- nutrient based on PP No.82 of 2001 (Bappedal 2002), the highest was in the spring in the middle and the lowest was in the downstream of watershed. The concentration of NO_3^- in the downstream (mg/l) and in the springs was tending to flow into river flow, both in the upstream and in the downstream (Table 1). Also NO_3^- concentration in the spring in the middle of watershed increased highly and returned to decrease after flowing into river flow in the downstream. The high concentration of NO_3^- in the spring can originate from agricultural activities in dry land in the upstream.

Usage of correction factor of N-NO_3^- by 4.427 to NO_3^- (Hach Company 1997) reached enrichment of NO_3^- nutrient in river water and in the spring of Yeh Sungi, toward class 2 quality standard of water on PP No 82 of 2001 (Bappedal 2002) as shown by Table 1. Table 1 shows that water enrichment by NO_3^- has occurred only in the springs in the middle that reaches 52.54% and only 0.01% in the upstream of the watershed is above quality standard by 10 mg/l in PP No. 82 of 2001 (Bappedal 2002). Subsequently, that most of NO_3^- in the water has not yet reached quality standard class 2 by 10 mg/l, except that enrichment in NO_3^- nutrient in Yeh Sungi water has not yet reached quality standard, except in the springs, both in the upstream and in the middle. In view of agriculture aspect, enrichment of NO_3^- nutrient in the water can benefit the farmer, but in view of environment were losses. It is benefit because N-NO_3^- nutrient becomes N source for the plant, thus can economically repress N input from outside such as urea and ZA fertilizer. It inflicted water environment because it can cause euthrofication that make various losses to the environment.

Enrichment of N Nutrient in River Water Flow of Yeh Sungi Watershed

NO_3^- nutrient in river water flowing from the upstream to the middle and from the middle to downstream has negative enrichment. NO_3^- concentration from the upstream to downstream was lower, that led to enrichment level become negative, namely -9.7 percent from upstream to the middle and -40.3 percent from the middle to downstream. This phenomenon occurred because of high urea

Table 1. List of Duncan Test Difference of the N-NO_3^- Concentration of the Springs and River Water and in Yeh Sungi Watershed, Tabanan, Bali, 2001/2002

Region	N	N-NO_3^- nutrient (mg/l)	Enrichment of NO_3^- nutrient (%)
Spring (upstream)	28	2.156 bc	-5.18 bc
Spring (middle)	14	3.446 a	52.54 d
River water (upstream)	21	2.295 b	0.01 c
River water (middle)	42	1.490 cd	-34.05 ab
River water (downstream)	21	1.182 d	-47.68 a

Notes:
1. Numbers with letter notation different with the same column means a significant difference (P=0.05)
2. N is the number of research sample
3. Value (-) means under quality standard, whereas value (+) means that of upper quality standard.

fertilizer usage in the middle and downstream, in line with the difference in farming practices implemented by the farmers and land area in each watershed location. Rice field in Yeh Sungi watershed was 2,688 ha, much greater than that in the upstream (28 ha) and also in the downstream (1,097 ha). Decrease of nitrate nutrient in the upstream to the middle showed that N nutrient utility had occurred in the river water flow expelled by thecrops in the upstream and the middle. Therefore, phenomena on reused N nutrient by crops in the upstream and middle have occurred.

Implementation of 3R Concept

Nutrient utilization in irrigated water was implementation of the 3R concept, i.e. *reused*. The utilization will decrease occurrence in enrichment of water nutrient, and that one of the concept, i.e. aspect of *reduced*. Decrease of N nutrient in surface run-off can repress the occurrence of euthrophication, then to conserve the environment. The other values of 3R concept were *recycling*. In subak ecosystem it can be implicated better because subak management in a watershed region was carried out in a form of that almost all subak in one watershed ecosystem would receive irrigation water. The subak in the upstream will receive irrigation water early than that of in the downstream. Irrigation water will flow from the upstream or high rice field region to the downstream or low rice field region. In this case, all nutrients containing in irrigated water in the upstream will flow to rice field region in the downstream. This cycle will continuously run as long as irrigated water has benefit to farming interest in subak ecosystem.

Utilization of stubbles or paddy straw as *mulsa* can become organic fertilizer matters, and caused to prevent lost of nutrient more than that in the rice field. Because the nutrient that previously transported with agricultural wastes, especially the stubbles will be returned if the farmers can implement sustainable activity. The concept of recycling in a wise environment management on the subak ecosystem can be run well, thus the farming practice in subak ecosystem will be sustainable. Implementation of the 3R concept in rice farming practice in subak ecosystem will be better off through lower inorganic fertilizer application rates because the nutrients can be provided by irrigation water and stubbles utilization as organic fertilizer. Decrease of N fertilizer usage will give a positive economy impact to the farmers in the scope of local and global, due to decrease of N nutrient concentration in the water. This condition will decrease euthropication cases or a negative externality of N existence in the water.

Rationalization and Impact of Fertilizer Utilization

Water nutrient utilization as nutrient source for the crops, at least will give the macro and micro implications. The micro implication concerned is decrease in urea fertilizer usage, related with nutrient availability in the water, such as carried out by the farmers in the upstream, this can reduce the cost of urea fertilizer usage. The macro implication is decrease in enrichment level of nutrient in the water, therefore can reduce water resources damage. This is inevitable can keep overall water and land ecosystem balance**.** The usage of fertilizer will consider nutrients containing in irrigated waters which follow mathematics rules based on nutrient balancing, there are depend on: (1) fertilizer types, (2) period of irrigation, (3) nutrient concentration in water, (4) nutrient need of the crops, (5) loss nutrient level, (6) nutrient concentration in the soil, and (7) other nutrients source such as stubbles, N fixation from the air and rainwater. Absorption level of N by the paddy at upstream with out inorganic fertilizer, showed that mostly of water nitrogen can be used by the paddy. Paddy crops at upstream absorb N from irrigation water is equal to 93.31 kg urea. This value is calculated in Table 2.

Table 2. Result of Calculated N Absorption in Water Irrigation for the Eice in Upstream of Yeh Sungi Watershed, Tabanan, Bali, 2001/2002

Nitrogen measure at	Nitrogen-nitrate ($N\text{-}NO_3^-$)	Same as urea or $CO(NH_2)2$
1. Inflow (mg/l)	1.82	141.52
2. Outflow (mg/l)	0.62	48.21
3. Used by rice plant	1.20	93.31
4. Effectivity (%)	66.00	66.00

Table 2 shows that the water irrigation is one of potential nitrogen sources for rice in subak ecosystem. Based on nitrogen balance (Dobermann & Fairhurst 2000) and the phenomena on Table 2, the nitrogen fertilizer in the subak ecosystem of Yeh Sungi watershed can be calculated and the result of the calculation showed on Table 3 as bellow. Table 3 shows that urea fertilizer need was 134.41 kg/ha in the upstream, 151.02 kg/ha in the middle area, and 155.63 kg/ha in the downstream region. This reveals that farmers will be more efficient on their farming system, if the nitrogen in the water irrigation used as a source of urea fertilizer. Use of nitrogen in the water irrigation as a source of urea has some advantages, not only for the farmers, but also for the environment, i.e., (1) decrease of the water enrichment; (2) slow down of the euthrophication accident; (3) preserving the good quality of water, (4) preserving good quality and growth of coral reef. To simply calculation in the field and to know how many kg of urea is needed, we could use Formula-1 below.

Formula-1. Calculation of urea fertilizer needed for rice plant, each planting season

Urea needed = [113- (29 x $N\text{-}NO_3^-$)] x 100/45 kg/ha each planting season

Remaks:

Urea = Urea fertilizer needed (kg/ha) each season

Table 3. Nitrogen Balance of Subak Ecosystem at Upstream, Middle and Downstream of Yeh Sungi Watershed, Tabanan, Bali, 2001/2002

Source and nitrogen loss	Location and nitrogen level (kg/ha)			Location and urea fertilizer sources and needed (kg/ha)		
	Upstream	Middle	Downstream	Upstream	Middle	Downstream
Source of nitrogen	217.50	217.50	217.50	483.33	483.33	483.33
1. Urea fertilizer	60.48	67.96	70.03	134.41	151.02	155.63
2. Soil	52.50	52.50	52.50	116.67	116.67	116.67
3. Biomass	42.00	42.00	42.00	93.33	93.33	93.33
4. Water irrigation	17,52	10.04	7.97	38.92	22.31	17.70
5. Fixation N from air	45.00	45.00	45.00	100.00	100.00	100.00
Nitrogen losses	165.00	165.00	165.00	367.00	367.00	367.00
1. In the plants	105.00	105.00	105.00	233.33	233.33	233.33
2. Leaching	10.00	10.00	10.00	22.22	22.22	22.22
3. Volatile	50.00	50.00	50.00	111.11	111.11	111.11

Aim to Dobermann & Fairhurst (2000)

113 = Nitrogen loss each planting season, if the productivity is 6 ton/ha, so have to be prepared from some sources another water irrigation

29 = quantity of N, calculated based on: (1) water flow 3 l/dt/ha; (2) irrigation period, is 40 days; (3) nitrogen absorption effectivity from water irrigation by rice plant is 66% (result of this research); (4) Moocule weigh of urea with formula is $CO(NH_2)_2$; (5) nitrogen in urea is 45%

CONCLUSION AND RECOMMENDATION

1. Difference in rice field farming practices in Yeh Sungi watershed region have caused difference in N nutrient concentration in the water, both in rice field water and river water. These differences have caused different water enrichment. $N\text{-}NO_3^-$ nutrient concentration is significantly higher in the upstream if compared to those in the middle and downstream. The nutrient enrichment can be utilized as nutrient sources for irrigated rice plant, therefore it reduces N fertilizer usage. Nitrogen nutrient utilization in irrigation water is one of the implementation of the 3R (*Reuse, Recycling, and Reduced*) concepts on environmental management. The concept implementation will reduce N fertilizer usage and water nutrient enrichment can maintain quality of water environment. Therefore, there is no reason for the subak's members not to implement 3R concept in their farming practices through subak system in Bali, and the concept of sustainable development in Bali will become realized.
2. This research recommends that application of urea fertilizer should consider nutrient availability in the soil, as well as N nutrient concentration in irrigation water, and to return the stubbles to rice field to implement the concept of environmental management in subak ecosystem. These efforts will give micro implications in the form of fertilizer economic cost decrease and macro implications in the form of reducing the load of N nutrient pollution in water, and finally it will maintain ecosystem balance.

REFERENCES

Badan Pengendalian Dampak Lingkungan.2002. Peraturan Pemerintah Republik Indonesia Nomor 82 Tahun 2001 tentang Pengelolaan Kualitas Air dan Pengendalian Pencemaran.

Dobermann A, T. Fairhurst. 2000. Rice Nutrient Disorder and Nutrient Management Rice Ecosystem, Nutrient Management, Nutrient Deficiencies, Mineral Toxicities, Tool and Information, 1st Edition International Rice Research Institute, the Philippines.

Gilliam JW, TJ. Logan, FE. Broadbent. 1997. Penggunaan Pupuk dalam Hubungannya dengan Lingkungan Teknologi dan Penggunaan Pupuk, Edisi Ketiga, Cetakan Pertama, Gajah Mada University Press, Yogyakarta. Penerjemah Didiek Hadjar Goenadi, Pusat Penelitian Perkebunan Bogor. Editor Bambang Radjagukguk. Terjemahan dari Fertilizer Technology and Use. Third Edition. Published by Soil Science Society of America, Inc.

Hach Company. 1997. Calorimeter Procedures Manual DR/890. All right reserved. Printed in USA.

Ongle ED. 1996. Control of Water Pollution from Agriculture FAO Irrigation and Drainage Paper 55. Food and Agriculture Organi-zation of the United Nations, GEMS-Water Collaborating Center Canada, Center for Inland Waters Burlington, Canada.

Pitana IG. 1997. Subak, Sistem Irigasi Tradisional Bali, Sebuah Canang Sari, Penerbit Upada Sastra Denpasar.

Reddy KR, EG. Flaig, DA. Gretz . 1996. Phosphorus Storage Capacity of Uplands, Wetlands and Streams of the Lake Okeechobee

Watershed, Florida. Agriculture Ecosystem and Environ-ment Elsevier Science, USA.

Reintjes C., B. Haverkort, AW. Bayer. 1999. Pertanian Masa Depan. Pengantar untuk Pertanian Berkelanjutan dengan Input Luar Rendah. Penerbit Kanisius, Cetakan Pertama. Terjemahan Y. Sukoco, SS dari Farming For The Future, An Introduction to Low-External Input and Sustainable Agriculture. The Macmillan Press, 1992.

Surdianto Y., Suriapermana, S. Nurhati I.1999. Efisiensi Pemupukan N pada Padi Berdasarkan Bagan Warna Daun (BWD). Tonggak Kemajuan Teknologi Produksi Tanaman Pangan. Konsep dan Strategi Peningkatan Produksi. Simposium Penelitian Tanaman Pangan IV. Bogor 22-24 November 1999. Pusat Penelitian dan Pengembangan Tanaman Pangan. Bahan Penelitian dan Pengembangan Pertanian.

Soegianto P. 2000. Pupuk dan Petani: Studi Kasus Adopsi Pupuk oleh Petani Carlauan, Laguna, Philipina. Cetakan Pertama, MedPrint Offset, Media Presindo Yogyakarta.

Vincent G. 1992. Teknik Analisis dalam Penelitian Percobaan. Penerbit Transito, Bandung.

Wilbur H. 2000. Impact of Nitrogen on the Environment and Health. Nitrate in the News. Special Report- June 2000- Nitrate Elimination Co, Inc. (NECI).

Yadav RL, DS. Yadav, RM. Singh, A. Kumar. 1997. Long Term Effect of Inorganic Fertilizer Input on Crop Productivity in a Rice Wheat Cropping System, Nutrient Cycling in Agroecosystem, 51:193-200, 1998. Kluwer Academic Publisher, Printed in the Netherland.