BUKTI KORESPONDENSI JURNAL INTERNASIONAL TROPIK 2: REKOMENDASI LAND USE PLANNING

Tsel-PakaiMasker 4G 14.23

aflizar melafu

editation P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
26 Jul 2010 jam 15.04

Dear sensei

I would like send editation of P2

I make small revision.

Thank you very much sensei

Sincerely yours

Aflizar

JLS297_Sumatra2_Edit[1] english ...

JLS297_Sumatra2_Tables[1] englis...

Tsel-PakaiMasker 4G 14.28

Revised P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
14 Jun 2010 jam 19.35

Dear sensei

I would like to report the revised P2

Thank you very much sensei

Sincerely yours

Aflizar

Cover P2 revised T.doc

Text P2 revised T.doc

Tsel-PakaiMasker 4G 14.31

aflizar melafu

Revised Paper 2

Dari aflizar_melafu@yahoo.com
Kepada Tsugiyuki MASUNAGA
24 Apr 2010 jam 09.12

Dear sensei

I would like give paper 2 to sensei

Thank you very much sensei

Sincerely your

Aflizar

Answer to reviewers 920. clr.doc

Tsel-PakaiMasker 4G 14.31

Tsugiyuki MASUNAGA

P2

Dari masunaga@life.shimane-u.ac.jp
Kepada aflizar melafu
22 Apr 2010 jam 16.46

af

Answer to reviewers 920.doc

Tabel P2 revised.doc

Text P2 revised.doc

Tsel-PakaiMasker 4G 14.32

aflizar melafu

Revised paper 2

Dari aflizar_melafu@yahoo.com
Kepada Tsugiyuki MASUNAGA
21 Apr 2010 jam 01.06

Dear Sensei

I would like send the revised paper 2.
I've improved my paper 2. however, I still have limited capabilities. I look forward sensei assistance to complete paper 2

After I completed the repairs of all the graphics for the paper 1 so as soon as I send to sensei

Tsel-PakaiMasker 4G 14.33

Revised paper 2

After I completed the repairs of all the graphics for the paper 1 so as soon as I send to sensei

Thank you very much for your help to me and my family.

Sincerely yours

Aflizar

Form 4_MS920[1].pdf

Tsel-PakaiMasker 4G 14.34

aflizar melafu

revised P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
28 Jan 2010 jam 16.34

Dear Sensei

I would like to give revised P2

I hope some comment from sensei

Thank you very much sensei

Sincerely yours

Aflizar

Tsel-PakaiMasker 4G 14.35

aflizar melafu

Revised P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
26 Jan 2010 jam 14.07

Dear sensei

I have already revised figure of second paper.

I would like give P2 to sensei

Thank you very much sensei

Sincerely your

Aflizar

Tsel-PakaiMasker 4G 14.36

Re: Revised P2

Dari masunaga@life.shimane-u.ac.jp
Kepada aflizar melafu
26 Jan 2010 jam 12.48

Af

> Dear sensei
> ?
> I hope sense always fine and success.
> ?
> I would like give revised of second paper to sensei.
> ?
> I have added some information to improve my second paper.
> ?
> I hope sense give me some comment.
> ?
> Thank you very much sensei.
> ?

Tsel-PakaiMasker 4G 14.36

Re: Revised P2

> I hope sense always fine and success.
> ?
> I would like give revised of second paper to sensei.
> ?
> I have added some information to improve my second paper.
> ?
> I hope sense give me some comment.
> ?
> Thank you very much sensei.
> ?
> ?
> Sincerely yours
> ?
> Aflizar
> ?
> ?
> ?
>
>

Tsel-PakaiMasker 4G 14.36

aflizar melafu

Revised P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
22 Jan 2010 jam 16.17

Dear sensei

I hope sense always fine and success.

I would like give revised of second paper to sensei.

I have added some information to improve my second paper.

I hope sense give me some comment.

Thank you very much sensei.

Tsel-PakaiMasker 4G 14.37

Revised P2

I would like give revised of second paper to sensei.

I have added some information to improve my second paper.

I hope sense give me some comment.

Thank you very much sensei.

Sincerely yours

Aflizar

All figure paper 2 rev 3.pdf

Tsel-PakaiMasker 4G 14.37

aflizar melafu

P2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
19 Jan 2010 jam 08.41

Dear sensei

I hope sensei always fine and happy in Indonesia.

I have revised P2 based on recommendation from sensei.
with my honest. I would like give P2 to sensei

Thank you very much sensei to improve my second paper.

I hope sensei, always fine and happy.

Sincerely yours

Tsel-PakaiMasker 4G 14.38

Kuniaki Sato

FW: 到着

Dari ksato@life.shimane-u.ac.jp
Kepada aflizar_melafu@yahoo.com
15 Jan 2010 jam 11.13

Af-san

Masunaga sensei order me to send his message and attached files to you.
Please read and send your comment to Masunaga sensei.

Gambatte

sato

Af,

Attached is the revised P2. Please read through

Tsel-PakaiMasker 4G 14.39

Word file of paper 2

Dari aflizar_melafu@yahoo.com
Kepada Masunaga Tsugiyuki
11 Jan 2010 jam 12.49

Dear sensei

I am sorry sensei,

I am late to reply and send the second paper to sense.

because I just open my email

Really sorry sensei

Sincerely yours

Aflizar

--- On **Sat, 1/9/10, Masunaga Tsugiyuki <*masunaga@life.shimane-u.ac.jp*>** wrote:

Tsel-PakaiMasker 4G 14.39

aflizar melafu

PDF file of paper 2

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp & 1 lainnya
8 Jan 2010 jam 08.59

Dear sensei

I would like give pdf file of paper 2 of me

thank you very much for your kindness

Sincerely yours

Aflizar

Cover page P2.pdf

Tsel-PakaiMasker 4G 14.39

aflizar melafu

P2 revised

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
21 Des 2009 jam 14.02

Dear sensei

I would like to send my second paper

Sincerely your

Aflizar

Cover page P2.doc

Tsel-PakaiMasker 4G 14.41

aflizar melafu

Second paper

Dari aflizar_melafu@yahoo.com
Kepada masunaga@life.shimane-u.ac.jp
2 Sep 2009 jam 14.10

Dear sensei

I would like send second paper of me to sensei

for anything mistake in my paper, firstly, I would like say, I am sorry very much

I would like say thank you very much for sensei help to me

Sincerely your

Aflizar

Tsel-PakaiMasker 4G 14.41

Second paper

Dear sensei

I would like send second paper of me to sensei

for anything mistake in my paper, firstly, I would like say, I am sorry very much

I would like say thank you very much for sensei help to me

Sincerely your

Aflizar

2-9-09 second paper.doc

All figure in P2.ppt

Tsel-PakaiMasker 4G 14.42

aflizar melafu

P2

Dari aflizar_melafu@yahoo.com
Kepada elviraflisevi@yahoo.com & 9 lainnya
2 Sep 2009 jam 13.46

Dear sensei

Allow to send my second paper

I would to say thank you very much on all help from sensei

Sincerely your

Aflizar

Tsel-PakaiMasker 4G 14.42

aflizar melafu

P2

Dari aflizar_melafu@yahoo.com
Kepada elviraflisevi@yahoo.com & 9 lainnya
2 Sep 2009 jam 13.46

Dear sensei

Allow to send my second paper

I would to say thank you very much on all help from sensei

Sincerely your

Aflizar

Answer to reviewer A

丁寧な査読およびコメントありがとうございます。ご指摘、コメントを頂きました点につきまして、以下のように修正いたしました。引き続き、ご審査のほどよろしくお願いいたします。修正内容を本文および本回答に青地で記述いたしました。

１）Study　areaの記載につきまして，Fig.1に前報（MS919）と同様に，S1~5のSub-watershedを示されたほうが分かり易いと思います．あるいは，Table 1に，S1~4のSub-watershedの名称をどこかに示されたらよいと思います．
Fig.1の表記を修正し、Table1表外にSub-watershedの名称を追加いたしました。

２）P4-L7　栽培されている野菜の面積（あるいは生産量）はどのようになっていますか？品目ごとに記載されている順番でしょうか？また，経営分析ではTomato，Radishがあげられていますが，これらの栽培はどのような状況でしょうか？
P4L21-：各作物の生産量による栽培の状況を表しました。

P9-L24に関連しますが・・・最終的な農家所得の試算では，野菜の収益性の平均値を用いられたのでしょうか？野菜は作物によって収益性が大きく異なり，どのような野菜を栽培するのかによって，収益性の予測結果が大きく異なると思います．述べられているように，この調査地域ではトマトは高収益が期待できますが，このような果菜類は高度な栽培技術が求められ，導入はかなり限られてくるのではないでしょうか．野菜の収益性の試算について，野菜の作付けの現状あるいは想定される状況（収益性を重視してトマトの作付けを振興するなど）を考慮して試算されるとどのようになりますか？　また，terraceやcontour　croppingを新たに導入すると，コストはどの程度加算されるのでしょうか？最終的に収益性の変化の試算では，このようなコストも考慮されたのでしょうか？
P6L16-, P7L23-：sawah,、vegetable garden、 mixed garden の各土地利用毎に平均値を求め、その値を集水域全体の収益の計算に用いいています。
ご指摘のように、厳密にはvegetable gardenでは mixed garden各作物毎の栽培面積や生産量により重みをつけて計算を行うべきですが、各sub-watershedレベルの詳細な収益に関するデータが得られない事から、上述のように平均値を今回用いました。Recommended　land　useにおけるterraceやcontour　croppingの導入につきまして、そのコストは含んでいませ

ん。これは、コメント９）への回答に記述しましたように、政府の土壌保全支援のためのプログラムがあり、これの活用を想定しているからです。このことに関しましても、追記をいたしました。

３）P7-L15　Sumani watershedにおける生産コストがCianjur watershedよりも低い理由は何でしょうか？
P8L18-Cianjur　watershedでは農民が土地を持たず借地料を地主に支払わねばならないためです。単純に二つの地域を比べて生産コストやB／Cが高い低いと述べるのは適切ではありませんでしたので、同じインドネシアの野菜栽培でも、借地料がかかるような地域では生産コストの増加、B／C比の低下が生じる事を記述するよう修正しました。

４）P7-L18　「the tolerable soil erosion」は，the tolerable soil erosion rateですね？あるいはTER.
５）P8-L3　上記と同様の指摘です．the tolerable soil erosion rate 表記をTERに統一されてはどうでしょうか.
語句をTERに修正、統一いたしました。

６）P8-L8　収益性ではそうですが，B/C　ratioの平均値で比較すると3つの土地利用に大差がないように見えます．B/C ratioはどのような意味を持つのでしょうか？
コストに対する収益獲得の効率を比較するための指標となります。
P6L5—：に意味について記述いたしました。

７）P8-L12　Table3は，Present　land　useは調査エリア全体のTERの状況を示しており，調査エリア全域を，個々の土地利用に置き換えた場合，TERがどのように変化するのかを示していると理解してよろしいですね．エリア全域をterraceやcontour　cropping無しの野菜生産に置き換えたデータがあると，terraceやcontour　croppingの効果がよく分かると思います．
P8L3-, Fig.3：記述が分かりにくいようでしたのでテキストおよびFig.3を修正いたしました。
　集水域全体を変える事はあまりにも非現実的ですので、現在の土地利用形態で土壌侵食速度がＴＥＲ以下のところは、そのままの土地利用とし、ＴＥＲを超えた場所の土地利用を個々の単一の土地利用に置き換えたシミュレーションです。

８）P9-L10　 Table2 に変化が数値として示されていますが，MS919のFig3bとFig.4の2002年の図も，本論文のFig.4 入れて比較すると，調査エリア内において，どの場所の土地利用がどのように変化し，どれだけ侵食抑制効果があるのかを明瞭にとらえると思います．MS919と同じ巻に掲載されるのであれば不要かもしれませんが.
MS919と同じ巻に掲載されることを考えており、本論文には掲載しませんでした。

９）P10-L20　インドネシア，あるいは調査地域では，新しい技術や情報（政策）は，十分に説明・議論され，補助金のような支援があれば，農民あるいは農村単位で容易に受け入れられる状況にあり，この成果は，実現可能性・導入可能性が高いと評価できますでしょうか？とくに，調査地域の農民は土壌浸食の状況をどの程度深刻にとらえているのでしょうか？（これは，論文内容に反映されなくても結構です．どのような状況なのか興味があります．）P3L15−（改訂原稿）：現地の農民が土壌浸食が深刻であると理解し、知識と経済的な支援があれば土壌保全活動を行いたいと考えている事、またインドネシア政府が土壌保全活動のためのプログラムを有するが、信頼のできる情報や土壌浸食防止計画がないために、事業が進んでいない事を、Introductionに追記いたしました。

Answer to reviewer B

Thank you very much for your review. We tried to revise the manuscript according to your and the other reviewer's comments as below.

Thank you very much for your further review in advance.

1) Fig. 3: "Agroforestry" is used as an axis label. However, mixed garden has been described in text. "Mixed garden" is appropriate to use as axis label.

P9L7-8: We added the sentence "Distributions of respective factors in the watershed were summarized in figures 2.". Then, explanation of Fig.2 appears before that of Fig.3.

Manuscripts

The title of the paper: A Recommendable Land Use Planning in Sumani Watershed, West Sumatera, Indonesia.

The full names of the authors:

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Type of the contribution: Full-length paper

Number of text pages: 16

Number of tables: 2

Number of figures: 4

Number of photographs:

Reprint order: 50

A short running title: A Recommendable Land Use Planning in Sumani Watershed.

（Format No. 2）

AGREEMENT

Date: June 1, 2010

To Dean of The United Graduate School of
Agricultural Sciences, Tottori University

Name of Joint Author: HERMANSAH Seal

Institute and Title of Position:

Faculty of Life and Environmental Science, Shimane University, Nishikawatsu 1060, 690-8504, Japan

Title of Publication:

A Recommendable Land Use Planning in Sumani Watershed, West Sumatera, Indonesia

Authorship:

Aflizar, Amrizal Saidi, Husnain, Ismawardi, Bambang Istijono, Hermansah, Hiroaki SOMURA, T
oshiyuki WAKATSUKI and Tsugiyuki MASUNAGA

Full Name of Scientific Journal with Volume, Number and Pages:

TROPICS, The Japan Society of Tropical Ecology

Published:☐ Accepted:☐
Published date or expected date to be published (Month and Year):

Table 1**.** Result of the economic feasibility analyses in Sumani watershed

S1= Sumani, S2= Lembang, S3= Gawan, S4= Aripan, S5= Imang sub-watershed, SW= Sumani watershed

[a] A common Indonesian local fruit.

Land utilization type	Range of soil erosion rate ($Mg\ ha^{-1}y^{-1}$)	Cost	Revenue (Production x price)	Benefit	Benefit-Cost ratio
		($US\$\ ha^{-1}y^{-1}$)			
Sawah					
Sawah at S1	0.010 – 6.32	183.76	1152.35	968.58	5.27
Sawah at S2	0.004 – 13.21	208.24	1124.22	915.98	4.40
Sawah at S3	0.003 – 13.18	265.18	1253.60	988.42	3.73
Sawah at S4	0.003 – 0.48	363.76	1339.50	975.73	2.68
Average	*1.0*	255.24	1217.42	962.18	*3.77*
Vegetables garden					
Pepper at S2 (*capsicum annum*)	0.386 – 893.0	1482.35	5269.80	3787.45	2.56
Tomato at S2 (*solonum lycopersicum.syn*)	0.386 – 893.0	1065.88	7617.06	6551.18	6.15
Radish at S2 (*raphanus sativus L.*)	0.386 – 893.0	373.13	1058.82	685.69	1.84
Red onion at S2 (*allium ascalonicum.L*)	0.386 – 893.0	2140.71	7058.82	4918.12	2.30
Mixed croping at S4	0.144 – 751.0	562.12	3011.76	2449.65	4.36
Mixed croping at S5	0.145 – 628.0	684.24	2964.71	2280.47	3.33
Average	*132.3*	1051.40	4496.83	3445.43	*3.28*

Mixed garden					
Duku[a] at S1 (*langsium domesticum*)	0.152 – 213.0	174.12	774.12	600.00	3.45
Duku at S2 (*langsium domesticum*)	1.928 – 348.0	204.71	804.71	600.00	2.93
Coconut at S3 (*cocos nucifera*)	0.457 – 523.0	245.65	1304.47	1058.82	4.31
Coconut at S5 (*cocos nucifera*)	61.457 – 556.0	245.65	1304.47	1058.82	4.31
Average	*66.9*	217.53	1046.94	829.41	*3.81*

Table 2. Change of land uses in the recommended land use planning.

	Present land use	Recommended land use
Soil erosion rate		
Average (Mg ha^{-1} y^{-1})	51.4	7.1
Range (Mg ha^{-1} y^{-1})	(0.001-1423.0)	(0.001-59.0)
Land use pattern (%)		
Forest	15.9	29.4
Sawah	23.3	27.6
Vegetable garden without conservation practices	24.9	5.6
Vegetable + terrace	0	10.0
Vegetable + contour cropping	0	1.8
Mixed garden	12.2	19.0
Grass	0.6	0.0
Alang-alang (*Imperata cylendrica)*	2.4	0.0
Shrub	3.7	0.0
Settlement	11.5	7.8
Settlement + home garden + terrace	0	3.7
Coconut	2	0.7
Tea	0.1	0.1
Water body	3.9	3.9
Total	100.0	100.0
Benefit from agricultural production (US $ million y^{-1})	66.85	64.26

US $ 1 equivalent to about Rp 8500 at the period of the study

ABSTRACT

In the present study, we tried to make a recommendation land use planning concerning land conservation and agro-economical production in a watershed, Sumani watershed in West Sumatra, Indonesia, where intensive agriculture has been practiced in long time. On the aspect of land conservation we used the results of soil erosion rates estimated using Universal Soil Loss Equation in the previous paper. We tried to make the recommendable land use planning more realistic by keeping current land uses as much as possible. In sites with the soil erosion rate less than the tolerable erosion rate (TER), 14 Mg ha^{-1} y^{-1}, set by Indonesian government, the land use was kept as it was. When soil erosion rate was higher than TER, we selected a new land use with a *CP*-factor smaller than the original one in order to reduce the soil erosion rate. In the recommended land use planning, 19.3% of the vegetable garden was changed into new land uses such as vegetable with terrace (10%), vegetable with contour cropping (1.8%) and sawah (7.5%). Recommended land use planning could reduce soil erosion rate by 86%, which is from 58.9 to 7.1 Mg ha^{-1} y^{-1}, with a reduction in total profit from agricultural production the only 2.8% in whole Sumani watershed.

Key words: recommended land use, soil erosion, *USLE*

INTRODUCTION

No soil phenomenon is more destructive in Indonesia than soil erosion caused by heavy rainfall and deforestation for expansion of agricultural fields to meet food increasing food demands. Soil erosion of 6-12 Mg $ha^{-1}y^{-1}$ on agricultural land has caused economic loss of US$ 340-406 million in Indonesia in 1989, which was responsible for nearly 80% of the decline in the productivity of agricultural land (World Bank, 1989). In recent years, demand for agricultural products has been further increased due to population growth (Sarainsong et al. 2007). This accelerated deforestation and land use changes without concerning about soil conservation in Indonesia. There is a rising call for a better land and watershed management planning to archive sustainable use of agricultural filed keeping its economical productivity and controlling soil erosion. But, it has never been conducted yet in Indonesia.

Sumani watershed where is the main rice production area in West Sumatra has been also facing rapid land use change from forest to agricultural fields and increase of soil erosion rate. Average soil erosion rate in the watershed estimated by Universal Soil Loss Equation increased from 43.13 Mg $ha^{-1}y^{-1}$ in 1992 to 58.91 Mg $ha^{-1}y^{-1}$ in 2002 with the change of land use pattern (Aflizar et al. 2010). In 52% of the land in the watershed, the soil erosion rate exceeded the tolerable erosion rate (TER) in Indonesia, i.e. 14 Mg $ha^{-1}y^{-1}$.

In Sumani watershed, farmers recognized that soil erosion was very serious in their agricultural land. Farmers are also willing to do soil conservation practices on their farmlands, if they could have proper knowledge and financial assistance. For realizing the conservation practices, Indonesian government provide a program to local governments in order to assist soil and water conservation practices conducted in agricultural fields in watershed scales. This program was known as the National Movement for Forest and Land Rehabilitation (GN-RHL/GERHAN) (Watershed Management Agency, 2007). The details can be seen in

Regionaldua (2007). Though there were farmer's demands and the program of the government for soil conservation practices, it has not progressed in Indonesia due to lack of correct and reliable information on soil erosion in watershed scales and planning idea for better watershed management. In a previous study, we tried to make precise evaluation on soil erosion in a typical agricultural watershed in Indonesia, Sumani watershed. Based on this work, we tried to make a recommended land use pattern of the watershed by modifying the land use types to reduce soil erosion less than TER keeping agro-economical production in the watershed in the present study. This is the first case study on a recommended land use planning based on the researches on soil erosion and agro-economic status in watershed scale in Indonesia. We hope we can show a realistic idea to local farmers and the government how to design soil conservation planning and to implement it in Indonesia.

MATERIALS AND METHODS

Study area

Sumani watershed, covering 58,330 ha, locates in Solok regency (latitude 00° 36' 08" to 10° 44´ 08´´ S, longitude 100° 24´ 11´´ – 101° 15´ 48´´ E) with the elevation of 300 m and 2500 m above sea level about 50 km east of the Padang city (Figure 1). Outlet of the watershed is Lake Singkarak. It is situated in a humid tropical zone. Sumani watershed consists of land uses such as primary forest, mixed garden, vegetable garden, sawah, abandoned agricultural field and settlement. The term sawah refer to a levelled and bounded rice field with an inlet and outlet for irrigation and drainage (Wakatsuki et al. 1998). Mixed garden refers to agricultural field where perennial tree crops such as rubber, cinnamomon, coffee, coconut, clove are planted with annual crops with average production of 103, 101, 61, 21 and 5 Mg y^{-1}, respectively. (Solok statistical agency, 2002). Sawo and avogado productions were unrecorded. In vegetable gardens, farmers mainly cultivated sweet potato (*Ipomoea batatas. L*), onion, tomato, chilli, corn (*Zea mays. L*) and soybean with average production of 9487, 3565, 1025, 783, 699 and 134 Mg y^{-1}, respectively (Solok Statistical Agency, 2001) . Detail description of the study site can be seen in the previous paper (Aflizar et al. 2010).

Estimation of soil erosion rate in watershed

In the previous paper (Aflizar et al. 2010), we estimated soil erosion rate in Sumani watershed using Universal Soil Loss Equation (Wischmeier and Smith, 1978). In the *USLE* model, annual soil loss is expressed as a function of six erosion factors:

$$E = R \text{ x } K \text{ x } L \text{ x } S \text{ x } C \text{ x } P \qquad (1)$$

Where: *E* is the estimated soil loss in Mg $ha^{-1}y^{-1}$; *R* is Rainfall erosivity factor, dimensionless; *K* is inherent soil erodibility, dimensionless; *L* is length of the slope factor, dimensionless; *S* is slope factor, dimensionless; *C* is crop cover factor, dimensionless; and *P* is a factor that accounts for the effects of soil conservation practices, dimensionless.

The watershed was divided by 39312 grids with the size of 125 m x 125 m mesh and basic data were allocated or estimated in each grid by means of reading of maps and a Landsat image for land use types and altitude or kriging method for precipitation and soil properties. Base on these data, respective *USLE* factors were calculated in each grid unit. Among the above factors, *C*- and *P*-factors are the ones that we can modify to improve soil erosion and agro-economical conditions in the watershed.

Economic feasibility analysis

Economic feasibility of respective land use types in the watershed was evaluated from its cost-benefit ratio, which was calculated as:

$$BC \text{ ratio} = \frac{R - C}{C} \qquad (2)$$

Where *R* is the revenue which is calculated as production (kg) x price (US$ kg^{-1}), *C* is cost (US$). BC ratio is shown as basic data to assess the efficiency of cost investment against to benefit gained from respective agricultural products. The BC ratio can be used as a guideline (ranging from 2.6-10.3) to prevent any loss of profit received by farmers at the next harvest due to large production costs (Choudhury et al. 1995; Slaney et al. 2010). In order to calculate these parameters, data on costs of labor, fertilizer, pesticide and seed, and production and price of respective agricultural products were derived from a detailed social economic survey report in Solok statistical agency in 2002 and Istijono (2006) that was the latest available data during the period of the study. As the both cost and revenue varied in the watershed, we summarized the results in sub-watershed levels where respective land uses were mainly distributed (Table 1). Land use types with no cost and revenue such as forest, and grass, *alang-alang* (land occupied by *Imperata cylindrica*) and shrub lands were omitted from the analyses. The average values of benefits in respective land uses of sawah, vegetable garden and mixed garden were calculated as representative values for the estimation and comparison of total profit of agricultural production in whole watershed in the present and the recommended land use planning.

Planning of recommended land use

Based on the resolute *USLE* factor values of each grid, the spatial distribution of soil erosion rates under present farming practices in Sumani watershed was established in the previous paper (Aflizar et al. 2010).

In order to a make recommended land use planning, we took procedures shown in Figure 2. The analyses were conducted in each grid unit. In grids with the soil erosion rate less than the TER, 14 Mg ha^{-1} y^{-1}, the land use type was kept in the recommended land use planning. In this process, all the grids with the land use of forest, sawah and tea showed the soil erosion rate less than TER and were kept as they were. When the soil erosion rate in a grid exceeded TER, we calculated *CP*-factors to meet TER by the formula "recommended *CP* = TER / (*R x K x LS*)" for the respective grids. Then we selected a new land use from candidates of new land uses. We separated the process for vegetable garden from mixed garden and bush, which consisted of grass, *alang-alang* (land occupied by *Imperata cylindrica*) and shrub, as shown in Figure 2. As vegetable garden has brought the highest agro-economical benefit among the land uses (Table 1), we tried to keep the land use with an application of conservation practices such as contour cropping and terracing to reduce soil erosion rate. In case that the recommended *CP*-factor was smaller than 0.008, we changed the land use into sawah. For land uses of mixed garden and bush, mixed garden with a soil conservation measure, i.e. full cover crop, or reforestation were applied depending on the recommended *CP*-factors. In addition to the processes in Figure 2, for the grids with settlement that located at steep slope area and showed soil erosion rate more than TER, soil conservation measure by home garden with fruit trees plus terracing was applied in order to reduce the soil erosion rate less than TER as shown in Table 2. Though the above processes, 58330 ha out of the whole watershed area was modified in the land uses. Change of land uses were summarized in Table 2. The cost of application of soil conservation measures was not counted in the calculation of benefit in recommended land use show in Table 2, as we expected that the cost will be supported by the governmental program described above.

In addition, we also tried to make a simple simulation to evaluate effects of application of respective land use types on reducing soil erosion. We assumed that the area with the soil erosion rate higher than TER under the present land use condition was converted into a single land use type listed in Figure 3. This meant that area with the soil erosion rate less than TER was kept as the original land use was. Although it was not realistic plannings, we could see the effects the application in comparison.

RESULTS AND DISCUSSION

Results of economic feasibility analysis

The results of economic feasibility analysis are shown in Table 1. The benefit was generally highest in vegetable gardens, which was about 3 to 4 times higher than those in sawah and mixed garden. Although farmers want to cultivate vegetables because of the higher benefit, suitable area for vegetable garden was limited in higher topographical positions with relatively cool climate. Vegetable garden shared about 25% of the whole watershed area (Table 2). Cost-benefit (B/C) ratio ranged from 1.84 to 6.15, which was higher comparing with vegetable garden in Cianjur watershed (B/C ratio of 1.1) in the central part of West Java (Sarainsong et al. 2007). In Cianjur watershed, although the revenue was about the same in both watersheds, production cost was three times higher than that in Sumani watershed because the farmers don't have their own land area and have to rent the lands from land-owners. The cost for vegetable production in Cianjur watershed was approximately U.S. $ 3,132 ha^{-1} y^{-1} with the BC ratio of 1.1 (Sarainsong et al. 2007) while that in Sumani watershed U.S. $ 1,051 ha^{-1} y^{-1} with the BC ratio of 3.28 in average (Table 1), which was three times as high as did Cianjur watershed. This meant we have to take the land cost into account for production and to expect lower benefit and B/C ratio in regions like Cianjur watershed. Sawah in all sub-watersheds possessed the soil erosion rates less than the TER. Sawah in S1 and S2 located in middle to upper topographical positions in the watershed, where harvest of rice was only one time a year. In spite of the one time harvest in S1 and S2, it had a higher B/C ratio than lowland sawah at S3 and S4 where farmers harvested twice or three times a year. This was mainly due to the rice quality. Quality of rice harvested in S1 and S2 were approved to be better, which might be owing to cool climate. Therefore, consumers preferred it and the selling price became more expensive than those in lowland in S3 and S4. For vegetable garden, it generally showed very high soil erosion rates, 132.3 Mg ha^{-1} y^{-1} in average, as they were located on sloping areas in the watershed. Most of the area with vegetable garden showed the values less than the TER. In terms of the B/C ratio, tomato garden had high production and high price, resulting in higher B/C ratio compare to pepper, radish, red small onion (*bawang merah* in Indonesian) and other vegetables. For mixed gardens, coconut garden had a higher B/C ratio than that of duku (*langsium domesticum*).

As we showed the large difference in benefit of respective land uses, we must keep land use of vegetable gardens in order to keep agricultural profit in the watershed.

Recommended land use planning

Figure 3 shows the results of a simulation applying single land use type on control of soil erosion rate on the area with the soil erosion rate higher than TER. Application of the vegetable gardens with soil conservation practices of contour cropping and terracing, could control the soil erosion rate less than TER at the area of 59% and 73% of total watershed area, respectively. Because of the mountainous topography and high annual rainfall in Sumani watershed, these conservation practices were not enough to control soil erosion in the agricultural land. Mixed garden and sawah were more effective in reducing soil erosion rates in the watershed. This was in agreement to the past research carried out in Indonesia which signify that mixed garden and sawah gave the best results by reducing soil erosion and increasing crop production (Kusumandari and Mitchell, 1997). Mixed garden and sawah could control the soil erosion rate in wider area, approximately 82% and 98 % of total watershed area, respectively. Mixed garden and sawah ranged had higher potential to control soil erosion rate as they have smaller *CP*-factors comparing with vegetable gardens. The *CP*-factor of mixed garden, sawah and vegetable garden were 0.01-0.08, 0.003-0.009 and 0.2, respectively. Plants used in mixed garden have multilayered canopies and cover ground efficiently prohibiting soil surface from being disturbed by rainfall. Sawah has bands surrounding the area, which is able to control both soil erosion and run off. As far as we concern the economical profit of the respective land use, vegetable garden was the preferable option, followed by mixed garden or sawah (Table 1). It was found that we had to apply reforestation for the sloping areas in order to control soil erosion rate in all the area less than TER.

Figure 4 shows the predicted soil erosion rate under a recommended land use planning in the watershed. Table 2 summaries the data on soil erosion rate, coverage percentages of respective land use types and benefit from agricultural production in the current and the recommended land use planning. Soil erosion rate under the recommended land use planning was predicted to be 7.1 Mg ha^{-1} y^{-1}, accounting for 86% of the reduction from that of the present land use condition. In the recommended land use planning, area of the coverage of vegetable gardens with contour cropping and terracing, mixed garden with full cover crop and sawah in the watershed area were 1.8, 13.7, 19.0 and 27.6% with the increment of 1.8, 10.0, 6.8 and 4.3% from the present land use condition, respectively (Figure 4 and Table 2). Application of the terracing in vegetable gardens is believed to be an effective measure in Sumani watershed as Zhang et al. (2003) also reported. The terracing, which is an effective method of soil conservation on steep slopes, has been used extensively to control water erosion in hilly areas and farmers in many countries.

With the application of the recommended land use planning to the watershed, we expected great reduction of soil erosion rate with very small reduction of agro-economic profit by only 2.9% from that in the present land use condition. It changed from 66.85 million US$ in current land use condition to 64.26 US$. In the present study, although we did not consider an option with rotation in sawah to increase the profit, it has high possibility of application. In fact, in upper topographical positions in the watershed, the rotation of rice and vegetables has been practiced by some farmers. However, there were also farmers who completely converted land use from sawah to vegetable garden to increase their agro-economical income, which surely resulted in the increase of soil erosion. Such demands of farmers should also been considered in the implementation of the planning. It may be a practical and effective land use planning to cultivate vegetable in less rain season and rice in heavy rain season to control soil erosion ensuring farmers' income.

In the sense of feasibility implementing the recommended land use planning, it is obviously impossible to implement it in the watershed at once. As Agus et al. (1997) and Crasswell et al. (1997) stated in their works, that use of appropriate agronomic practices is preferable to reduce soil erosion with low cost whenever it is possible. We should proceed the application of better watershed management practices step by step, whenever it is possible. Actually, there is a case that land use conversion is inevitable to practice agriculture on very steep slopes, even though government or researchers do not push farmers (Svoray et al. 2005; Sarainsong et al. 2007). This means there was a natural motivation to apply soil conservation practices in the area. In this case, what government and researchers have to do is providing appropriate information and advises to farmers or local government for better watershed management. The recommended land use planning in the present study is an practical example.

In the recommended land planning, reforestation was applied to the sites with bush (grass, shrub and *alang-alang*) and some sites with mixed garden on the very step slope. The reforestation was possible to be implemented because these sites have not been productive in the present land use condition and planting of trees has been a common practice in mixed garden. In contrast, application of soil conservation practices such as contour cropping and terracing in vegetable gardens were rather difficult because it costs and requires skills for farmers. Incentives or subsidies to the farmers from the central or local governments and other sectors such as National Electricity Agency which is a stake holder of Sumani watershed management may be necessary to apply the recommended land use planning. As Stevenson and Lee (2001) and Sarainsong et al. (2007) reported, the strategies and management activities should be discussed and elaborated by local peoples, government and other stakeholders before the implementation of the planning.

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Fig. 1. Study site and distribution of soil sampling points sites in Sumani watershed, West Sumatra, coordinates bases on UTM coordinate system WGS 84 Zone 47 Southern Hemispire.

Fig. 2. Planning process model: E, Estimated soil erosion, TER, Soil loss tolerance for economic planning (14 Mg $ha^{-1}y^{-1}$), *CP*-factor: crop factor x protection factor of *USLE*, Vg: Vegetable garden, MG: Mixed garden.

Fig. 3. Effect of respective agricultural land use types on controlling soil erosion rates in the Sumani watershed. This is a simulation assuming that all the area in the watershed, except forest is converted to respective land use types, except "Present land use". Total watershed area is 58330 ha.

Fig. 4. Predicted soil erosion rate (a) under Recommended land use pattern (b)