Attachment-H.1

Determination of L,C and P Factors
for USLE

Attachment-H.1 Determination of L, C and P Factors for USLE

1 Preliminary Estimate of Soil Loss

1.1 L factor

L factor is determined based on the 1:50,000 topographycal map and confirmed by field observations (See Figure HAT1.1 to 1.7).

(1) Irrigated rice

Usually rice lands has 20 to 50 m of the length of surrounding ridges. Based on this fact, length of paddy land was determined.

L = 40m

(2) Maize

Determined by field measurement. Because observation shows that maize is planted in the furrows between the ridges in some places and another places applies opposite manner planted on the ridges as shown in Figure I.1.2 to I.1.7. The depth of the furrows is about 20 cm with 40 to 60 cm wide and interval of the ridges is 60 cm mostly. In any manner of planting, the furrow stores water and accumulates eroded soils from the ridges. Judging from this fact, slope length of the maize could be 1 m.

L = 1m

(3) Vegetables

Decided by field observation, L = 1 m. They applies high bed for vegetable farming. Depth of the furrows is 20 to 50 cm with 60 cm wide. Width of ridge is 80-90 cm as shown Figure I.1.8. Based on the observation, slope length for vegetable farm was decided.

L = 1m

(4) Estate with good cover

Slope length of the estates is decided by field observation, about 30% of estates is applied agro-forestry using the land for mostly maize cultivation.

Slope length of the estate with grass cover is measured in the 1:50,000 topo-map. Average number of the ridge dividing water flow is 4.01 in one square element having side length of 465m each. The number of slopes is calculated two times of number of ridges. Average length of the slopes determined is L = 58 m.

Based on the field observation, slope length is measured 1m in the estates with maize farming. Crop farming is introduced to 30% of the estate and 70% of estates

is covered with good vegetation of trees and grasses, regarded equivalent to permanent Alan-Alan with its length of 58 m. Length of estate assumed as below.

L = 0.3 x 1 + 0.7 x 58 = 0.3 + 40.6
= 40.9 m

(5) Secondary forest and natural forest

Same manner was applied to these categories. Average number of ridges in one element is 4.01, and then the number of slope divided is two times of number of ridges. Finally average length of the slopes determined by 1:50,000.

L = 58 m

(6) Estate-crop farming mixture

The meaning of this category is that canopies of the tree crops covers 20 to 70 % of the square element of 465m side length each. Average slope length is calculated by the assumption of 50% of the area being estate and 50% of the area of cropping land. The slope length is Lest = 40.9 m for the estates and 50 % is Lveg = 1m.

L = 0.5 x Lveg + 0.5 x Lest = 0.5 x 1 + 0.5 x 40.9 = 0.5 + 20.4
= 20.9m

(7) Urban area

Based on average size of residential plots.

L = 25m

(8) Values of Slope Length

Based on above procedures, determined values of slope length is tabulated in following by land use.

Slope Length

Land Use/Crops	Slope Length (m)
Irrigated rice	40.0
Maize	1.0
Vegetables	1.0
Estate with good cover	40.9
Secondary forest	58.0
Natural forest	58.0
Estate-vegetable mixed area	20.9
Estate-crops mixed area	20.9
Urban area	25.0
Wetland	50.0

1.2 C-factor

C-factor is determined based on the recommended values with some modification

by field observation.

(1) Irrigated rice

The recommended value was adopted.

C = 0.01

(2) Maize

According to the field observation, maize is not cultivated throughout the year. Most of the farms are used as one crop in one year and the fields are left covered with grasses in remained 8 months. C factor for maize is decided based on this fact by following way. Growing period (C = 0.64) is 4 months followed by 3 months of growing stage of grass (C = 0.1 of annual Alan-Alan), and 5 month covered with grown grass (C = 0.02 of permanent Alan-Alan). C is calculated as below.

C = (4 x 0.64 + 3 x 0.1 + 4 x 0.02)/12 = 0.245

(3) Vegetables

Applied recommended value;

C = 0.7

(4) Estate

About 30% of estate are mixed with crop cultivation. Remained 70% are consisted of only tree estate crops with dense cover of grasses.

In the estates of tree crops without crop cultivation, such as coconut and clove, ground surface observed completely covered with thick vegetation and difficult to see the ground. It means surface condition is similar to pasture with good cover (C = 0.04) or permanent Alan-Alan (C = 0.02). Here we applied Cest = 0.02 for the estate without crop cultivation.

In the estate with crop farming, maize is planted dominantly by rotation cropping. Rotation cycle is 4 years mostly and maize is harvested every fourth year. Other 3 years period, they left the land covered with thick vegetation. Here, the assumption is that for the first year, the ground surface is covered 4 months with maize (C=0.245), 6 months with growing stage of grasses equivalent to annual Alan-Alan (C=0.100), 2 months with grown grasses. Remained 3 years also covered with grown grasses equivalent to perennial Alan-Alan (C=0.02).

Cmix = (0.245 x 4/12 + 0.1 x 3/12 + 0.02 x 5/12 + 0.02 x 3) /4
= 0.044

By above assumption, C-factor of the estate is computed as below considering 70%

of estates is with thick covering grasses (C=0.02 equivalent to Alan-Alan) and 30% of estates is with crop farming under the trees (C=0.044).

C = 0.7 x Cest. + 0.3 x Cmix = 0.7 x 0.02 + 0.3 x 0.044
= 0.027

(5) Secondary forest

C = 0.005 (with poor litter)

(6) Forest

C = 0.001 (with undisturbed with good litter)

(7) Estate-vegetable mixed

Assume 50% of vegetable land and 50% of estate crops with good cover.

C = 0.5 x 0.7 + 0.5 x 0.027 = 0.364

(8) Estate-maize mixed

Assume 50% of maize, and 50% of estate with good cover

C = 0.50 x 0.245 + 0.5 x 0.027 = 0.136

(9) Urban area

Land use pattern is complicated in urban area. Observation by the aerial photo indicates use and their proportion as below table.

Land Use Pattern in Urban Area

Use	Houses	Roads (paved)	Trees	Mixed garden/vegetables	Open
Share	0.30	0.10	0.30	0.25	0.05
C-factor	0.00	0.00	0.10	0.40	1.00

C-factor for the urban area was calculated as below.

C = 0.3 x 0 + 0.1 x 0 +0.3 x 0.1 +0.25 x 0.4 +0.05 x 1
= 0.18

(10) Values of C factor

C factors applied in the calculation of erosion are shown in following table.

C factors

Vegetation	C
Irrigated rice	0.010
Maize	0.245
Vegetables	0.700

Estate crops with good cover	0.027
Forest with sparse cover	0.005
Forest with good cover]	0.001
Estate-vegetable mixture	0.364
Estate-maize-peanut mixture	0.136
Urban area	0.180
Wetland	0.010

1.3 C factor by RUSLE

On the other hand, according to RUSLE (Revised Universal Soil Loss Equation, C-factor is expressed as a function of SLR (Soil Loss Ration). SLR is a function of PLU for prior-land-use sub-factor, CC for canopy cover sub-factor, SC for surface cover sub-factor, SR for surface roughness sub-factor, and SM for soil moisture sub-factor as shown below. C factor is expressed using SLR (Soil Loss Ratio) as following.

SLR = PLU * CC * SC * SR * SM

Where,

SLR: soil-loss ratio for the given condition,

PLU: prior-land-use sub-factor,

CC: canopy-cover sub-factor,

SC: surface-cover sub-factor,

SR: surface roughness sub-factor, and

SM: soil-moisture sub-factor

SLR is calculated for each time interval, they are multiplied by their corresponding percentage of annual EI. Then these values are summed and divided by the total percentage of annual EI value for the entire period.

C = (SLR1*EI1 + SLR2*EI2 + ……. +SLRn*EIn)/Eit

Using above formula, C-factors for maize and grass were calculated. C of maize was 0.038, and of grasses 0.037 on growing stage, 0.004 on grown stage. However, C = 0.02 is applied for grown grasses as equivalent to permanent Alan-Alan.

C-factor for grass and maize cultivation was calculated as follows by RUSLE.

For annual maize cultivation, assumptions were grown period was 4 months followed by 3 months of growing stage of grass, and 5 month covered with grown grass.

C = (4 x 0.038 + 3 x 0.037 + 5 x 0.02)/12 = 0.03

For permanent grasses, C-factor was calculated 0.02.

1.3 P factor

(1) Irrigated rice

Paddy rice field stores water and the condition is considered same to the bench terraces in good condition. Here, P is applied 0.04.

(2) Maize

In the study area, recent improvement of farming method improves the P-value. The fields cultivating maize observed applying contour farming with ridges and furrows as mentioned above. It is observed that the ridges did not break-over even after extreme rainfall. It is assumed to apply P = 0.15 of the good ridge terrace.

(3) Vegetables

Vegetable farm is applying high beds in the area. P value is applied 0.15.

(4) Estate

There is no special support practice in estates. However, if the land is used for crop cultivation, same manner to maize is applied. Area adopted contour cropping is 30%.

P = 0.3 x (Pridge) + 0.7 x 1 = 0.3 x 0.15 + 0.7 x 1 = 0.745

(5) Secondary forest

P value applied 1.0 as no support practice is applied for forest.

(6) Natural forest

P value applied 1.0 as the same reason to the secondary forest.

(7) Estate-vegetable mixed

Assumed 50% of the area is for estate and 50% for vegetables.

P = 0.5 x 0.15 + 0.5 x 0.745 = 0.448

(8) Estate-maize mixed

Assumed 50% of the area is for estate and 50% for maize. P value is.

P = 0.5 x 0.15 + 0.5 x 0.745 = 0.448

(9) Urban area

The areas are covered with densely built houses, mostly with surrounding walls, and it assumed condition is similar to bench terrace. P value applied is 0.15 as bench

terrace with average condition.

(10) Wetland

There is no measures/practice applied for such area, then P value is 1.0.

(11) Values of P factor

Values of P factor above are tabulated in following table.

P factors

Land Use	P factor
Irrigated rice	0.040
Maize	0.150
Vegetables	0.150
Estate	0.745
Secondary Forest	1.000
Natural Forest	1.000
Estate with vegetables	0.448
Estate with maize	0.448
Urban area	0.150
Wetland	1.000

2 Factors changed by Soil Erosion Control Measures

When soil conservation works will be implemented in the estate and arable upland, estate mixed with annual crop farming area will increase by introduction of agroforestry. Following table shows a comparison of present land use with future land use after implementation of conservation works.

Comparison on Land Use in Estate

Slope (%)	Present		Future	
	w/o farming	w/ farming	w/o farming	w/ farming
25-40	20	0	20	0
15-25	20	0	10	10
8-15	30	10	0	40
<8	0	20	0	20
Total	70%	30%	30%	70%

Comparison on Land Use in Mixed Estate

Slope (%)	Present		Future	
	w/o farming	w/ farming	w/o farming	w/ farming
25-40	10	0	10	0
15-25	30	0	10	20
8-15	10	30	0	40
<8	0	20	0	20
Total	50%	50%	20%	80%

The L, C, and P factors for the USLE could change by implementation of soil conservation measures. The changed values are shown below.

2.1 L- factor

L-factors for irrigated rice, arable uplands, natural and secondary forest, urban area, and wetland will not change.

(1) Estate with good cover

In the estates, by introducing agroforestry, annual crop produce will increase in the area of slope gradient less than 25% and multi-layer tree cropping will expand in the area of slope gradient of 15%. Finally it is expected 30% of estate will be covered with good vegetation, on the other hand, 70% of estate will be used with maize planted agro-forestry plot.

Slope length of estate covered with good vegetation is measured L = 58 m.

Slope length is measured 1m in the estates with maize. Area with maize will be 70% of the estates and 30% of estates will be with good vegetation cover, equivalent to permanent Alan-Alan with its length of 58 m. Length of estate assumed as below.

L = 0.7 x 1 + 0.3 x 58 = 0.7 + 17.4 = 18.1 m

(2) Estate-crop farming mixture

Average slope length is calculated by the assumption of 20% of the area being estate and 80% of the area maize grown. The slope length is Lest = 18.1m for the estates and Lmaz = 1m for agricultural land with maize.

L = 0.8 x Lmaz+ 0.2 x Lest = 0.8 x 1 + 0.2 x 18.1 = 0.8 + 3.62
= 4.4m

Slope Length

Land Use/Crops	Slope Length (m)
Irrigated rice	40.0
Maize	1.0
Vegetables	1.0
Estate with good cover	18.1
Secondary forest	58.0
Natural forest	58.0
Estate-vegetable mixed area	4.4
Estate-crops mixed area	4.4
Urban area	25.0
Wetland	50.0

2.2 C-factor

C-factor for irrigated rice, maize, forest, and urban area will not be changed after implementation.

(1) Estate

About 70% of estate will be mixed with crop cultivation. Remained 30% will be consisted of multi-layer tree crops with dense canopy.

In the estates of multi-layer tree crops, ground surface will completely covered with dense tree canopy. Here we applied Cest = 0.02 for estate with multi-layer tree crops.

In the estates with crop farming, maize is planted by rotation cropping. Therefore, the same value was applied as shown mentioned in paragraph 1.3.2 (5).

Cmix = 0.044

By above assumption, 30% of estate is covered with multi-layer trees and 70% of estates is with crop farming. C-factor of the estate is computed as below.

C = 0.3 x Cest. + 0.7 x Cmix = 0.3 x 0.02 + 0.7 x 0.044 = 0.037

(2) Estate-vegetable mixed

Vegetable land will be changed into maize dominant farming. Assume 80% of maize and 20% of estate crops with good cover.

C = 0.8 x 0.245 + 0.2 x 0.027 = 0.201

(3) Estate-maize mixed

Assume 80% of maize, and 20% of estate with good cover

C = 0.80 x 0.245 + 0.2 x 0.027 = 0.201

(4) Changed values of C factor

C factors applied in the calculation of erosion after implementation of erosion control measures are shown in following table.

C factors

Vegetation	C
Irrigated rice	0.010
Maize	0.245
Vegetables	0.700
Estate crops with good cover	0.037
Forest with sparse cover	0.005
Forest with good cover]	0.001
Estate-vegetable mixture	0.201
Estate-maize-peanut mixture	0.201
Urban area	0.180
Wetland	0.010

2.3 P factor

P factor for irrigated rice, maize, vegetables, forest, urban area, and wetland will not change by implementation.

(1) Estate

There is no special support practice in estates. However, when the land will be used for crop cultivation, same manner to maize will be applied. Contour cropping will be adopted in 70% of the area.

P = 0.7 x (Pridge) + 0.3 x 1 = 0.7 x 0.15 + 0.3 x 1 = 0.405

(2) Estate with vegetables

Assumed 20% of the area is for estate and 80% for vegetables.

P = 0.8 x 0.15 + 0.2 x 0.745 = 0.269

(3) Estate with maize

Assumed 20% of the area is for estate and 80% for maize. P value is.

P = 0.8 x 0.15 + 0.2 x 0.745 = 0.269

(4) Changed values of P factor

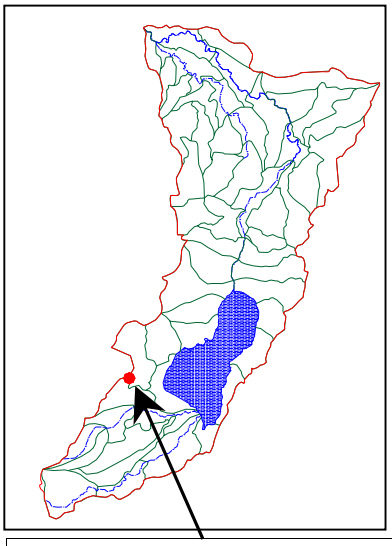
P factors applied in the calculation of erosion after implementation of erosion control measures are shown in following table.

P factors

Land Use	P factor
Irrigated rice	0.040
Maize	0.150
Vegetables	0.150
Estate	0.405
Secondary Forest	1.000
Natural Forest	1.000
Estate with vegetables	0.269
Estate with maize	0.269
Urban area	0.150
Wetland	1.000

<Farming Practice Type 1>

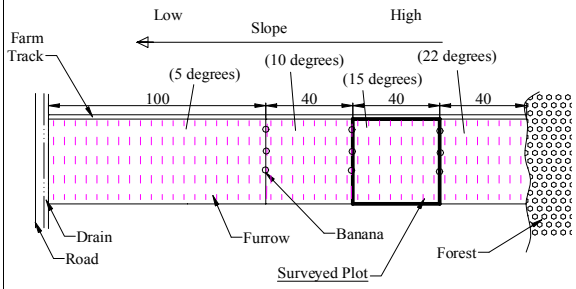
Cereal (Maize) with Ridge Terrace



Survey Data

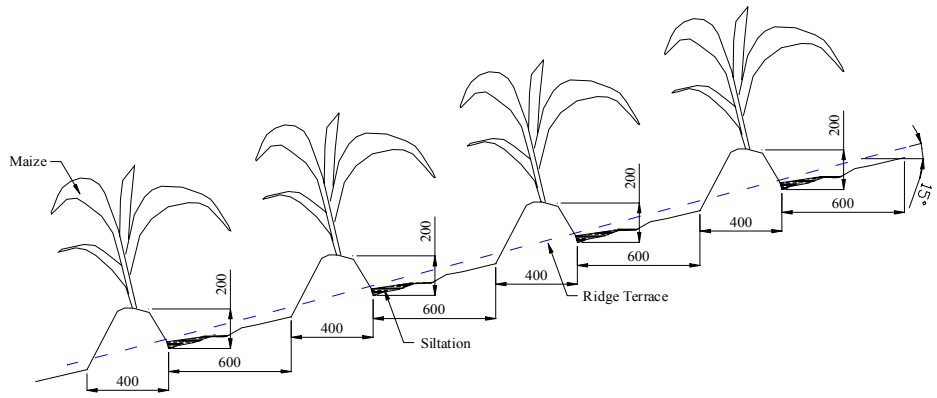
Date	: 22 Apr 2000
Location	: Pulutan - Tondegesan Kabupaten Kawangkoan (N01°15'37", E124°52'08")
Altitude	: 720m
Planted Crop	: Maize
Slope Angle	: 15°
Plot Size	: 0.14ha
Support Practice	: Ridge Terrace

Plan (not in scale)



(Unit : m)

Profile (not in scale)

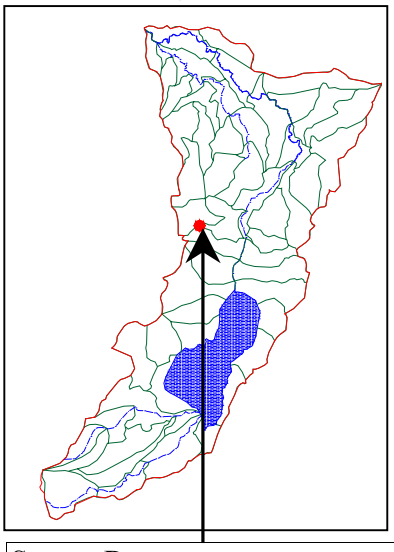


(Unit : mm)

The Study on Critical Land and Protection Forest Rehabilitation at Tondano Watershed in the Republic of Indonesia	**Figure HAT1.1 Typical Farming Practice - Cereal (Maize)**
Japan International Cooperation Agency	

<Farming Practice Type 2>

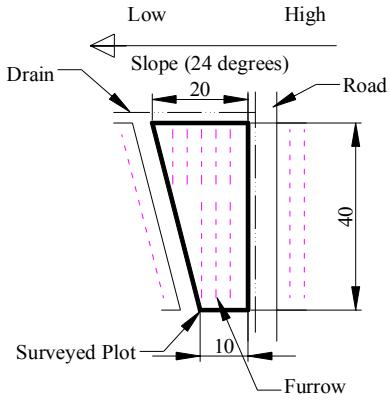
Vegetable (Carrot) with High Beds



Survey Data

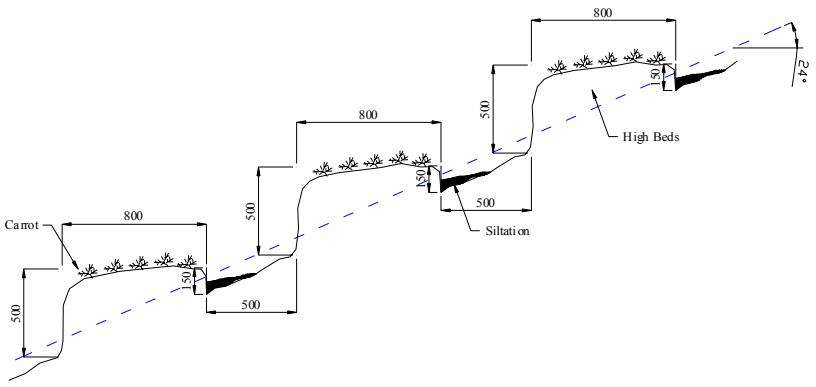
Date	: 22 Apr 2000
Location	: Rurukan Kabupaten Tondano (N01°20'16", E124°53'06")
Altitude	: 960m
Planted Crop	: Carrot
Slope Angle	: 24°
Plot Size	: 0.05ha
Support Practice	: High Beds

Plan (not in scale)



(Unit : m)

Profile (not in scale)



(Unit : mm)

The Study on Critical Land and Protection Forest Rehabilitation at Tondano Watershed in the Republic of Indonesia	**Figure HAT1.2 Typical Farming Practice - Vegetable**
Japan International Cooperation Agency	