

**ZONATION AND INTEGRATED PLANT NUTRIENT MANAGEMENT
STRATEGIES AND OPTIONS IN TANZANIA**

Volume V. SELECTION OF SUITABLE AREAS FOR FOLLOW-UP, GUIDELINES AND
ANNEXES

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1 .SELECTION OF PARTICULAR ZONES OR MAPPING UNITS FOR FOLLOW-UP BY IPNM/SFI

The selection has taken place on basis of population density, rainfall conditions, market orientation, soil conditions and fallow possibilities (intensification/extensification).

The selection categories for IPNM/ISFM are given in Table 1-1.

Table 1-1. Selected areas for future IPNM/ISFM/SFI

Category A. Mainly related to crop responses and sustaining crop productivity

Area	Population	Rainfall	Market orientation	Soil conditions	Fallow
A1	high	good	high	good	no
A2	high	good	medium to high	good	no
A3	high	medium	high	good	no

Category B. Intensification, soil conservation, inputs related to labour returns, inputs on cash crops

B1	high	good	low to medium	good	no
B2	high	good	low	poor	no
B3	high	medium	low	good	no

Category C. General soil fertility management

C1	medium	good	medium	good	some
C2	medium	medium	medium	good	some

Category D. Low input strategies and use of local resources, intensification, use of inputs related to economic returns and returns to labour

D1	medium	good	low	good	some
D2	medium	good	low	poor	some
D3	medium	medium	low	good	some
D4	medium	medium	medium	medium	some
D5	medium	medium	low	poor	some

Category E. Low input strategies for particular crops combined with manure and compost, inputs related to returns to labour and economic returns

E1	medium	medium	high	good	some?
E2	medium to high	medium	medium (to high)	medium to poor	some?

Category F. Inputs on specific cash crops only, related to returns to labour, use of little rock-phosphate and manure to sustain crop productivity, use of local resources, intensification

F1	medium	medium	low	medium	some
F2	medium	medium	low	good	some

Category G. Use of local resources, little if any fertilizer use on cash crops

G	low	good	low	good	possible
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Category K. Only fertilisation of cash crops, but doubtful. Use of local resources mainly.

K	low to medium	medium	low to medium	variable	possible
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Table 1-2 gives the areas selected for each category

Table 1-2. Location of selected areas

Selection category	Location
Southern Highlands	
A1	Mbeya, Rungwe, Njombe
A1	Kyela
A3	Mbeya plain
B1	Ludewa, Matengo
B3	Mufindi, Ubena
B3	Mbozi
C1	Rungwe (gneiss)
C2	Iringa
D1	Mbinga, Lupembe-Niave, Songea
D2	Karema, Lake Tanganyika/Nyasa shore areas
D4	Yambamrizi
D5	Namanyere-Laela
D5	Kate-Mwazye
D5	SE-Tunduru
G	Eastern Iringa highlands
K2	Rocky terrain Mbeya-Mbozi
K2	Lukosi, lower Mufindi
K3	Uruwira, Inyonga
K4	Nkansi-Kasanga
K4	Katumba, Busando
K4	Songea (sandstone, B5h)
K5	Gumbiro
K5	Rukwa valley/floodplain, Rukwe/Songwe valley
Northern zone	
A1	Meru, Kilimanjaro (Pe1)
B3	Pare mountains
E1	Meru, Kilimanjaro (Mc2, maize, bean)
E1	Hanang, Meru, Kilimanjaro (Mc2, dry, bean)
K2	Karatu
Eastern zone	
A2	Usambara, Morogoro, Mahenge
B2	East-side of Zanzibar/Pemba
B3	Mpwapwa highlands
D5	Muheza
E2	Hinterland coastal sand plains (A4d)
F1	Kilombero
F2	Hinterland plains (A4)
F2	Rufiji, coastal floodplains
K2	Mpwapwa medium altitude plains, Kilosa-west
K4	Mahenge basin, Mkulula valley, wet Eastern lowlands, Eastern plains (B5d), Eastern footslopes (B5)
Lake zone	
B2	Bukoba
B2	Sengerema, Ukerewe
B3	Tarime
B3	Mara floodplain
D4	Kahama-Bukombe (FSZ 5,6)
E1	Itogolo (FSZ 2)
E2	Luseni/Itogolo (FSZ 1)
F1	Kagera floodplain
F2	Biharamulo, South-western Kagera
Western zone	
D1	Kigoma highlands

D3	Kasuli-Kibombo
K3	Western plateau, Tabora plain, Bukombe, Sikonge-Msisi
K4	Katumba, Kigoma lakeshore
Central zone	
B3	Mpwapwa highlands
K2	Mpwapwa medium altitude plains
Southern zone	
D4	Coastal plains
D5	Masisi, Nachingwea
F2	Hinterland plains (A4)
F2	Coastal floodplains
K4	Southern plains (B4, B5)

1.1. Category A

Category A areas are characterized by a high population density, medium to good rainfall conditions, relatively high market orientation, good soil conditions and no fallow possibilities. IPNM/ISFM for category A should be determined in relation to crop responses and practices to sustain crop productivity.

Category A1

- Population: high
- Rainfall: good
- Market orientation: high
- Soil conditions: good
- Fallow: no
- Agro-ecological zones: Me-2c (unit A3a), Vo-1a (units Ala1, Ala2, Alb, Alc, Alg1, Alg2), Vo-1b (units Alh1, Alh2), Vo-1c (units Alk1, Alk2)
- Three different areas:
 - Mbeya, Rungwe, Njombe
 - Meru, Kilimanjaro
 - Kyela
- Soil fertility management issues: fertilizer input, intensification with recycling of nutrients, inputs related to returns to labour, inputs to cash crops related to economic returns

Strategy type	IPNM strategy	Numbers for zone Me-2c (Kyela)	Numbers for zone Vo-1a/1b (Rungwe, Mbeya)	Numbers for zone Vo-1c (Meru, Kilimanjaro)
Labour strategies	Shallow soils		1	1
	Restoration of soil fertility		4	
Labour and knowledge strategies	Improvement of soil fertility	10-18		
	Increase organic matter content of topsoil		19	
	Combat water erosion		27	27, 29
	Shallow soils		33, 34	33, 34
	Flooded soils	37		
	Poorly or imperfectly drained soils	38		
External input strategies	Nitrogen fertilizers	40, 42, 43	40, 42, 43	44
	Rock-phosphate	45, 47, 48	45, 47, 48	45, 47, 48
	Phosphate fertilizers		50, 51, 53	50, 51, 53
	Liming, ash			69
Government strategies	Landslides		86?	
	Flood control	87		
	Erosion control			88

Required inputs for all areas:

- Rock-phosphate

Specific requirements for each area:

- Kyela: urea
- Volcanic areas: urea, TSP

Category A2

- Population: high
- Rainfall: good
- Market orientation: medium to high
- Soil conditions: good
- Fallow: no
- Agro-ecological zones: Gn-1b (units Ald4-7)
- Location: Usambara, Morogoro highlands, Mahenge
- Soil fertility management issues: intensification with more recycling of nutrients, small quantities of inputs to be made available by retail, soil conservation measures and policies, fertilizer use, some problems if market situation is relatively poor: out-migration, feed constraints for livestock, fragmentation of land, soil degradation problems)

Strategy type	IPNM strategy	Numbers for zone Gn-1b
Labour strategies	Shallow soils	1
	Restoration of soil fertility	4
Labour and knowledge strategies	Improvement of soil fertility	8, 9, 10-18
	Increase organic matter content of topsoil	19
	Combat water erosion	27, 29
	Shallow soils	33, 34
	Dry soils	35
External input strategies	Nitrogen fertilizers	40, 42, 43, 44
	Rock-phosphate	49
	Phosphate fertilizers	50, 51, 53
	Liming, ash	69
Mechanisation/draught strategies		72, 73
Government strategies	Landslides	86
	Erosion control	88

Required inputs:

- Urea, TSP/SSP
- Rock-phosphate and liming materials to be supplied in small quantities

Category A3

- Population: high
- Rainfall: medium
- Market orientation: high
- Soil conditions: good
- Fallow: no
- Agro-ecological zones: Vo-4a (unit Clc)
- Location: Mbeya stepped plain

- Soil fertility management issues: fertilizer input, depending on rainfall conditions, intensification, crop responses related to returns to labour and drought risk

Strategy type	IPNM strategy	Numbers for zone Vo-4a
Labour and knowledge strategies	Combat water erosion	27, 29
External input strategies	Nitrogen fertilizers	40, 42, 43
	Rock-phosphate	45, 47, 48
	Phosphate fertilizers	50, 51, 53
Government strategies	Erosion control	88

Required inputs:

- Urea, rock-phosphate and TSP

1.2. Category B

Category B is characterized by a high population density, medium to good rainfall conditions, low to moderate market orientation. IPNM/ISFM should be determined in relation to intensification, soil fertility conservation. Input use should be related to returns to labour and should be applied on cash crops in the first place.

Category B1

- Population: high
- Rainfall: good
- Market orientation: low to medium
- Soil conditions: good
- Fallow: no
- Agro-ecological zones: Gn-1b (units Alj1-3)
- Location: Ludewa, Matengo
- Soil fertility management issues: input use related to returns to labour, intensification, could show good crop responses to inputs, out-migration, feed constraints for livestock, fragmentation of land, soil degradation problems

Strategy type	IPNM strategy	Numbers for zone Gn-1b
Labour strategies	Shallow soils	1
	Restoration of soil fertility	4
Labour and knowledge strategies	Increase organic matter content of topsoil	19
	Combat water erosion	27, 29
	Reduce leaching losses	31
	Shallow soils	33, 34
	Dry soils	35
External input strategies	Nitrogen fertilizers	40, 42, 43, 44
	Rock-phosphate	49
	Phosphate fertilizers	50, 51, 53
	Liming, ash	69
Mechanisation/draught strategies		72, 73
Government strategies	Landslides	86
	Erosion control	88

Required inputs:

- Urea, TSP/SSP
- Rock-phosphate and liming materials to be supplied in small quantities

Category B2

- Population: high
- Rainfall: good
- Market orientation: low
- Soil conditions: poor
- Fallow: no
- Agro-ecological zones: Co-1a (unit A3c), Ka-2 (units A2a1, A2a2), Me-2b (unit A2b)
- Three different locations:
 - East-side of Zanzibar/Pemba

- Bukoba
- Sengerema, Ukerewe
- Soil fertility management issues: inputs related to particular (cash) crops, out-migration, feed constraints for livestock, fragmentation of land, soil degradation problems but water (run-off) erosion of less importance than elsewhere

Strategy type	IPNM strategy	Numbers for zone Co-1a (Zanzibar-Pemba)	Numbers for zone Ka-2 (Bukoba)	Numbers for zone Me-2b (Sengerema Ukerewe)
Labour strategies	Shallow soils	1	1	1
	Restoration of soil fertility		5	4
Labour and knowledge strategies	Improvement of soil fertility		8, 9, 10-18	10-18
	Increase organic matter content of topsoil			19
	Combat wind erosion			25, 26
	Combat water erosion		27, 29	27, 29
	Reduce leaching losses	30?	30, 31	
	Shallow soils	33, 34	33, 34	33, 34
	Dry soils	35		35
	Poorly or imperfectly drained soils		38	
External input strategies	Nitrogen fertilizers	40, 42, 43	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	49		45, 47, 48, 49
	Potassium fertilizers		54, 55, 56	
	NPK-fertilizers	57?	57	
	Special inputs		61-66, 67	
	Liming, ash	68?	68, 69	69
Mechanisation/ draught strategies		73	71	72, 73
Research/ extension strategies	Crop response data, crop choice, varieties		79, 80, 82	
Government strategies	Erosion control		88	88

Required inputs for each area:

- Zanzibar/Pemba: urea, small quantities of rock-phosphate
- Bukoba: CAN, TSP/SSP, K₂SO₄, likely MgSO₄, CuSO₄, ZnSO₄, cattle licks, liming materials
- Sengerema, Ukerewe: CAN/urea, rock-phosphate, liming materials, possibly K₂SO₄

Category B3

- Population: high
- Rainfall: medium
- Market orientation: low
- Soil conditions: good

- Fallow: no
- Agro-ecological zones: Gn-3 (units Bld1-6, B2i), Lw-2b (unit B2e2), Vo-2 (unit Bld), Vo-4b (unit Cla)
- Four different areas:
 - Mufindi, Ubena, Pare, Mpwapwa highlands
 - Mbozi
 - Tarime
 - Mara floodplain
- Soil fertility management issues: intensification, input use related to returns to labour, out-migration, feed constraints for livestock, fragmentation of land, soil degradation problems, some drought risk in fertiliser use

Strategy type	IPNM strategy	Numbers for zone Gn-3 (Mufindi Ubena, Mpwapwa, Pare)	Numbers for zone Lw-2b (Mara)	Numbers for zone Vo-2 (Mbozi)	Numbers for zone Vo-4b (Tarime)
Labour strategies	Shallow soils	1			
	Restoration of soil fertility	2, 3, 4		4	2, 3
	Grazing				6, 7
Labour and knowledge strategies	Improvement of soil fertility		10-18		10-18
	Increase organic matter content of topsoil	19, 20, 21		19	19, 20, 21
	Combat wind erosion				25, 26
	Combat water erosion	27, 28, 29		27, 29	27, 28, 29
	Reduce leaching losses	(31)			
	Shallow soils	33, 34			
	Dry soils				35
	Flooded soils		37		
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	45, 46, 47, 48	45, 47, 48	45, 47, 48	45, 46, 47, 48, 49
	Phosphate fertilizers	50, 51, 53	50, 51, 53	50, 51, 53	50, 51, 53
	Potassium fertilizers		54, 55, 56		
	NPK-fertilizers	58, 59, 60	58, 60		58, 59, 60
	Liming, ash	69	69	69	69
Mechanisation draught strategies		71, 72			71, 73
Research/extension strategies	Crop response data, crop choice, varieties				81
Government	Flood control		87		

strategies					
	Erosion control	88		88	88

Required inputs in all areas:

- Urea, rock-phosphate, TSP/SSP

Specific required inputs:

- Mufindi, Ubena, Pare, Tarime, Mbozi: NPK, liming materials
- Mpwapwa: NPK, especially liming materials
- Mara floodplain: NPK, K_2SO_4 and liming materials

1.3. Category C

Category C is characterized by a moderate population density, moderate to good rainfall conditions, a moderate market orientation, good soil conditions and no fallow. IPNM/ISFM for this category deals with general soil fertility management practices.

Category C1

- Population: medium
- Rainfall: good
- Market orientation: medium
- Soil conditions: good
- Fallow: some
- Agro-ecological zones: Gn-1a (unit Alh3)
- Location: Rungwe-south (on gneiss)
- Soil fertility management issues: fertilizer use could be developed depending on actual soil fertility problems and management

Strategy type	IPNM strategy	Numbers for zone Gn-1a
Labour and knowledge strategies	Combat water erosion	27, 29
External input strategies	Nitrogen fertilizers	40, 42, 443, 44
	Phosphate fertilizers	50, 51, 53
	Liming, ash	69
Government strategies	Erosion control	88

Required inputs:

- Urea, TSP, some liming materials

Category C2

- Population: medium
- Rainfall: medium
- Market orientation: medium
- Soil conditions: good
- Fallow: some
- Agro-ecological zones: Gn-6a (unit D1b1)
- Location: Iringa plain
- Soil fertility management issues: fertilizer use could be developed depending on actual rainfall and actual soil fertility problems and management

Strategy type	IPNM strategy	Numbers for zone Gn-6a
Labour strategies	Shallow soils	1
	Restoration of soil fertility	4
	Grazing	6, 7
Labour and knowledge strategies	Increase organic matter content of topsoil	19
	Combat wind erosion	25, 26
	Combat water erosion	27, 29
	Shallow soils	33, 34
	Dry soils	35
External input	Nitrogen fertilizers	40, 42, 43

strategies		
	Rock-phosphate	49
	Phosphate fertilizers	50, 51, 53
Mechanisation/ draught strategies		73
Community strategies	Irrigation	75
Research/extension strategies	Crop response data, crop choice, varieties	81

Required inputs:

- Urea, rock-phosphate, TSP/SSP

1.4. Category D

Category D is characterized by a moderate population density, moderate to good rainfall conditions, low to moderate market orientation and some fallow possibilities. For IPNM/ISFM in this category there are low input strategies and use of local resources, intensification, while use of inputs should be related to economic returns and returns to labour.

Category D1

- Population: medium
- Rainfall: good
- Market orientation: low
- Soil conditions: good
- Fallow: some
- Agro-ecological zones: Gn-2 (units A2d1-3, A2d6-7), Ka-1 (Ale, Alf)
- Two different locations:
 - Mbinga, Lupembe-Niave, Songea
 - Kigoma highlands
- Soil fertility management issues: good crop response to fertiliser expected, input use related to returns to labour, intensification, out-migration, little fertilizer use due to high input prices and low availability depending on actual soil fertility problems and management, cash cropping only when storage of produce is organized

Strategy type	IPNM strategy	Numbers for zone Gn-2 (SH)	Numbers for zone Ka-1 (Kigoma)
Labour strategies	Shallow soils	1	1
	Restoration of soil fertility	4	4, 5
Labour and knowledge strategies	Improvement of soil fertility		8, 9, 10-18
	Increase organic matter content of topsoil	19	19
	Combat water erosion	27, 29	27, 29
	Reduce leaching losses	31	30, 31
	Shallow soils	33, 34	33, 34
	Dry soils	35	
External input strategies	Nitrogen fertilizers	40, 42, 43	40, 42, 43, 44
	Rock-phosphate	49	45, 47, 48
	Phosphate fertilizers	50, 51, 53	50, 51, 53
	NPK-fertilizers		57, 58, 60
	Special inputs		61-66
	Liming, ash		67, 68, 69
Mechanisation/ draught strategies		72, 73	
Government strategies	Landslides	86	
	Erosion control	88	88

Required inputs for both areas:

- Urea, TSP/SSP

Specific requirements for each area:

- Mbinga, Songea, Lupembe-Niave: small quantities of rock-phosphate
- Kigoma highlands: rock-phosphate, NPK, liming materials and possibly micro-nutrients

Category D2

- Population: medium
- Rainfall: good
- Market orientation: low
- Soil conditions: poor
- Fallow: some
- Agro-ecological zones: Me-2a (units A2c, A2d4, A2e)
- Location: Karema depression, Lake Tanganyika and Nyasa shores
- Soil fertility management issues: out-migration, little fertilizer use due to high input prices and low availability, fertilizer need or intensification needed to keep soils fertile, cash cropping only when storage of produce is organized

Strategy type	IPNM strategy	Numbers for zone Me-2a
Labour strategies	Shallow soils	1
	Restoration of soil fertility	4
Labour and knowledge strategies	Improvement of soil fertility	10-18
	Increase organic matter content of topsoil	19
	Combat water erosion	27, 29
	Shallow soils	33, 34
	Dry soils	35
	Flooded soils	37
	Sodic or alkaline soils	39
External input strategies	Nitrogen fertilizers	40, 41, 42, 43, 44
	Rock-phosphate	45, 47, 48, 49
	Phosphate fertilizers	52
	Liming, ash	69
Mechanisation/ draught strategies		73
Community strategies	Irrigation	75
Government strategies	Flood control	87
	Erosion control	88

Required inputs:

- Urea, rock-phosphate, some liming materials

Category D3

- Population: medium
- Rainfall: medium
- Market orientation: low
- Soil conditions: good
- Fallow: some
- Agro-ecological zones: Ka-3a (unit B1e)
- Location: Kasuli-Kibombo medium altitude plains

- Soil fertility management strategy: out-migration, little fertilizer use due to high input prices and low availability depending on actual rainfall and actual soil fertility problems and management, cash cropping only when storage of produce is organized

Strategy type	IPNM strategy	Numbers for zone Ka-3a
Labour and knowledge strategies	Combat water erosion	27, 29
	Dry soils	35
External input strategies	Nitrogen fertilizers	40, 42, 43
	Rock-phosphate	49
	Phosphate fertilizers	50, 51, 53
Mechanisation/ draught strategies	NPK-fertilizers	58, 60
		73
Government strategies	Erosion control	88

Required inputs:

- Urea, TSP/SSP, NPK, some rock-phosphate

Category D4

- Population: medium
- Rainfall: medium
- Market orientation: medium
- Soil conditions: medium
- Fallow: some
- Agro-ecological zones: Co-2a (unit B3m2), Me-4a (units B2a1-2, B2j1-2, B2k)
- Location:
 - Yambamrizi, Kahama-Bukombe
 - Southern coastal plains
- Soil fertility management issues: out-migration, little fertilizer use due to high input prices and low availability, depending on actual rainfall and actual soil fertility problems and management, cash cropping when storage of produce and transport to nearest market is organized, more recycling, higher efficiency in plant nutrient use and management, intensification, input use related to labour returns, input use on cash crops related to economic returns, drought risk in input use

Strategy type	IPNM strategy	Numbers for zone Co-2a (S)	Numbers for zone Me-4a (LZ, SH)
Labour strategies	Shallow soils		1
	Restoration of soil fertility	2, 3, 4	2, 3, 4
	Grazing		6, 7
Labour and knowledge strategies	Improvement of soil fertility		10-18
	Increase organic matter content of topsoil	19, 20, 21	19, 20, 21
	Combat wind erosion	25, 26	25, 26
	Combat water erosion		27, 28, 29

	Shallow soils		33, 34
	Dry soils	35	35
	Flooded soils		37
External input strategies	Nitrogen fertilizers	40, 42, 43	40, 42, 43, 44
	Rock-phosphate	46, 49	45, 46, 47, 48, 49
	NPK-fertilizers	59	59
	Liming, ash		69
Mechanisation/ draught strategies		72, 73	71, 72, 73
Community strategies	Irrigation	75	
Research/extension strategies	Crop choice, varieties		81
Government strategies	Flood control		87
	Erosion control		88

Requirements for all areas:

- Urea

Specific requirements for each area:

- Yambamrizi, kahama-Bukombe: rock-phosphate, some NPK and liming materials
- Coastal plains: some rock-phosphate and NPK

Category D5

- Population: medium
- Rainfall: medium
- Market orientation: low
- Soil conditions: poor
- Fallow: some
- Agro-ecological zones: Me-3 (unit B1c), Me-4b (units B3c3, B3d1-2, B3h2), Me-6a (unit D1a)
- Three different areas:
 - Namanyere-Laëla
 - Kate-Mwazyë
 - South-eastern Tunduru, Masisi, Nachingwea, Muheza
- Soil fertility management strategy: out-migration, little fertilizer use due to high input prices and low availability depending on actual rainfall, fertilizer need or intensification needed to keep soils fertile, cash cropping only when storage of produce is organized, water (run-off) erosion of less importance than elsewhere, intensification, crops response related to economic returns

Strategy type	IPNM strategy	Numbers for zone Me-3 (Kate-Mwazyë)	Numbers for zone Me-4b (S, E)	Numbers for zone Me-6a (Namanyere-Laëla)
Labour strategies	Shallow soils	1	1	
	Restoration of soil fertility	2, 3, 4	2, 3, 4	4
	Grazing		6, 7	
Labour and knowledge strategies	Improvement of soil fertility	10-18	10-18	10-18

	Increase organic matter content of topsoil	19, 20, 21	19, 20, 21	19
	Combat wind erosion	25, 26	25, 26	
	Combat water erosion	27, 28, 29	27, 29	27, 29
	Shallow soils	33, 34	33, 34	
	Dry soils	35	35	
	Flooded soils			37
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	45, 46, 47, 48, 49	45, 46, 47, 48, 49	45, 47, 48, 49
	NPK-fertilizers	59	59	
	Liming, ash	69	69	69
Mechanisation draught strategies		71, 73	72, 73	
Community strategies	Irrigation			75
Research/extension strategies	Crop response data, crop choice, varieties		81	81
Government strategies	Flood control			87
	Erosion control	88		

Requirements for all areas:

- Urea, rock-phosphate, liming materials

1.5. Category E

Category E is characterized by moderate to high population density, moderate rainfall conditions, moderate to high market orientation. IPNM/ISFM should be determined in relation to low input strategies for particular crops combined with manure and compost, while inputs should be related to returns to labour and economic returns.

Category E1

- Population: medium
- Rainfall: medium
- Market orientation: high
- Soil conditions: good
- Fallow: some?
- Agro-ecological zones: La-1 (unit B2l2), Vo-3 (units B2b1-2), Vo-5b (units D2k1, D2k3)
- Three different areas:
 - Meru, Kilimanjaro, wetter parts
 - Hanang, Meru, Kilimanjaro, drier parts
 - Itogolo (FSZ 2, Lake zone)
- Soil fertility management issues: fertilizer use is risky, but worth considering for cash crops, intensification, manure use important, drought risk in relation to input use, inputs related to labour and economic returns

Strategy type	IPNM strategy	Numbers for zone La-1 (Itogolo)	Numbers for zone Vo-3 (NZ, wetter parts)	Numbers for zone Vo-5b (NZ, drier parts)
Labour strategies	Shallow soils		1	1
	Restoration of soil fertility	3	2	
	Grazing	6, 7	6, 7	6, 7
Labour and knowledge strategies	Improvement of soil fertility		8, 9, 10-18	
	Increase organic matter content of topsoil		19, 20, 21	
	Combat wind erosion	25, 26	22, 23, 24	22, 23, 24
	Combat water erosion	27, 29	27, 28, 29	27, 29
	Reduce leaching losses		31	
	Shallow soils		33, 34	33, 34
	Dry soils	35	35	35
	Poorly or imperfectly drained soils	38		
	Sodic or alkaline soils	?		39
External input strategies	Nitrogen fertilizers	40, 42, 43	40, 42, 43, 44	40, 41, 42, 43
	Rock-phosphate	46, 49	45, 47, 48, 49	45, 47, 48, 49
	Phosphate fertilizers	50, 51, 53	50, 51, 53	50, 51, 52, 53
	NPK-fertilizers			58, 60
	Liming, ash		69	

Mechanisation draught strategies		73	72, 73	73
Community strategies	Irrigation		74	
Research/extension strategies	Crop response data, crop choice, varieties	81	79-81	81
Government strategies	Erosion control		88	

Required inputs for all three areas:

- Urea, TSP

Specific required inputs for each area:

- Volcanic areas: rock-phosphate, some NPK

Category E2

- Population: medium to high
- Rainfall: medium
- Market orientation: medium, high in some parts of Sukumaland
- Soil conditions: medium to poor
- Fallow: some, possibly none
- Agro-ecological zones: Co-3a (unit B3k), Lw-2c (unit B211)
- Two different areas:
 - Luseni-Itogolo (FSZ 1, Lake zone)
 - Hinterland (A4d) (Eastern zone)
- Soil fertility management issues: fertilizer use is risky, but worth considering for cash crops; intensification with manure, rock-phosphate use is needed to keep crop production sustainable, inputs especially on cash crops, intensification needed, out-migration?

Strategy type	IPNM strategy	Numbers for zone Co-3a (EZ)	Numbers for zone Lw-2c (LZ)
Labour strategies	Restoration of soil fertility	4	2, 3, 4
	Grazing		6, 7
Labour and knowledge strategies	Improvement of soil fertility		8, 9, 10-18
	Increase organic matter content of topsoil	19	19, 20, 21
	Combat wind erosion		25, 26
	Combat water erosion	27	27
	Reduce leaching losses		30
	Dry soils	35	35
	Poorly or imperfectly drained soils		38
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	45, 47, 48, 49	45, 46, 47, 48, 49
	Phosphate fertilizers		50, 51, 53
	Potassium fertilizers		54, 55, 56
	NPK-fertilizers		58, 59, 60
	Special inputs		63
	Liming, ash	69	69
Mechanisation/		73	72, 73

draught strategies			
Community strategies	Irrigation		74
Research/extension strategies	Crop response data, crop choice, varieties		79-82

Required inputs for both areas:

- Urea, rock-phosphate, some liming materials

Specific required inputs for each area:

- Luseni/Itogolo: SSP, K₂SO₄, NPK, boron

1.6. Category F

Category F is characterized by a moderate population density, moderate rainfall conditions, a low market orientation. IPNM/ISFM should deal with inputs on specific cash crops only, related to returns to labour, intensification, the use of little quantities of rock-phosphate and the use of local resources as manure to sustain crop productivity.

Category F1

- Population: medium
- Rainfall: medium
- Market orientation: low
- Soil conditions: medium
- Fallow: some
- Agro-ecological zones: Ka-4b (units B2e1, D2p3), Me-4c (unit B3a)
- Two different locations:
 - Kilombero
 - Kagera floodplain
- Soil fertility management issues: fertilizer use is risky, but could be applied on specific cash crops, like vegetables if produced for the market (transport to market should be organized). Intensification with manure use and rockphosphate and legumes cultivation is needed. Probably some out-migration. Low risk of input use, crop responses important for cash crops, intensification

Strategy type	IPNM strategy	Numbers for zone Ka-4b (Kagera)	Numbers for zone Me-4c (Kilombero)
Labour strategies	Restoration of soil fertility		2, 3
Labour and knowledge strategies	Improvement of soil fertility		10-18
	Increase organic matter content of topsoil		19, 20, 21
	Flooded soils	37	37
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	45, 47, 48	45, 46, 47, 48
	NPK-fertilizers		59
	Liming, ash	69	69
Government strategies	Flood control	87	87

Required inputs for both areas:

- Urea, rock-phosphate, liming materials
- Specific required inputs for each area:
- Kilombero: possibly NPK

Category F2

- Population: medium
- Rainfall: medium
- Market orientation: low
- Soil conditions: good

- Fallow: some
- Agro-ecological zones: Co-2b (unit B3l1), Co-3b (unit C3f), Ka-4c (units B2f2, B2f4), Me-5b (units B3b, B3i)
- Three different areas:
 - Hinterlands plains (A4, Eastern and Southern zone)
 - Rufiji valley, coastal floodplains (Eastern zone)
 - Biharamulo, south-western Kagera (Lake zone)
- Soil fertility management issues: fertilizer use is risky, but could be applied on specific cash crops, like vegetables if produced for the market (transport to market should be organized). Some intensification with manure use and rockphosphate and legumes cultivation is needed. Probably some out-migration. relatively little risk of input use, crop responses related to labour returns in the first place, intensification

Strategy type	IPNM strategy	Numbers for zone Co-2b and 3b (Hinterland plains)	Numbers for zone Me-5b (Rufiji, floodplains)	Numbers for zone Ka-4c (Kagera)
Labour strategies	Restoration of soil fertility	2, 3, 4	2, 3	4
Labour and knowledge strategies	Improvement of soil fertility		10-18	10-18
	Increase organic matter content of topsoil	19, 20, 21	19, 20, 21	19
	Combat wind erosion	25, 26	25, 26	
	Combat water erosion			27, 29
	Dry soils	35	35	35
	Flooded soils		37	
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43
	Rock-phosphate	45, 46, 47, 48, 49	45, 46, 47, 48, 49	44, 45, 47, 48, 49
	Phosphate fertilizers			50, 51, 53
	Potassium fertilizers			54, 55, 56
	NPK-fertilizers	59	59	58, 60
	Special inputs			61-66
	Liming, ash	69	69	69
Mechanisation draught strategies		72, 73	73	73
Community strategies	Irrigation		75	
Government strategies	Flood control		87	
	Erosion control			88

Required inputs for all areas:

- Urea, rock-phosphate, liming materials, possibly NPK

Specific required inputs for each area:

- TSP/SSP, possibly micro-nutrients

1.7. Category G

Category G is characterized by a low population density, good rainfall conditions, a low market orientation and sufficient fallow possibilities. IPNM/ISFM deals with the use of local resources with little if any fertilizer use on cash crops.

Category G

- Population: low
- Rainfall: good
- Market orientation: low
- Soil conditions: good
- Fallow: possible
- Agro-ecological zones: Gn-1b (units Ald1, Ald3)
- Location: Eastern Iringa highlands
- Soil fertility management issues: less scope for fertilizer use.

Strategy type	IPNM strategy	Numbers for zone Gn-1b
Labour strategies	Shallow soils	1
	Restoration of soil fertility	4
Labour and knowledge strategies	Increase organic matter content of topsoil	19
	Combat water erosion	27, 29
External input strategies	Shallow soils	33, 34
	Dry soils	35
	Nitrogen fertilizers	40, 42, 43, 44
	Rock-phosphate	49
	Phosphate fertilizers	50, 51, 53
Mechanisation/ draught strategies	Liming, ash	69
		72, 73
Government strategies	Landslides	86
	Erosion control	88

Required inputs:

- Urea, TSP, some rock-phosphate and liming materials

1.8. Category K

Category K is characterized by a low to moderate population density, moderate rainfall conditions, low to moderate market orientation and sufficient fallow possibilities. IPNM/ISFM should deal with the use of local resources, and possibly fertilisation of cash crops.

Category K2

- Population: low to medium
- Rainfall: medium
- Market orientation: low to moderate
- Soil conditions: good
- Fallow: possible
- Agro-ecological zones: Gn-4 (unit B2p2), Gn-5a (unit C1b), Gn-5b (units C1d1-2), Vo-3 (units B1a1-2)
- Four different areas:
 - Karatu
 - Rocky terrain north of Mbeya and around Mbozi plateau
 - Lukosi, lower Mufindi
 - Mpwapwa medium altitude plains, Kilosa-west
- Soil fertility management issues: less scope for fertilizer use, unless economic returns can be expected from cash crops and depending on availability of inputs and transport costs to the nearest market as well as storage costs. Some input use possible, depending on soil type, cash crop and on returns to labour. In some areas there is a drought risk influencing input use.

Strategy type	IPNM strategy	Numbers for zone Gn-4 (Mpwapwa)	Numbers for zone Gn-5a (RT-Mbeya-Mbozi)	Numbers for zone Gn-5b (Lukosi-Mufindi)	Numbers for zone Vo-3 (Karatu)
Labour strategies	Shallow soils		1	1	1
	Restoration of soil fertility	2, 3, 4	2, 3, 4	2, 3, 4	2
	Grazing	6, 7		6, 7	6, 7
Labour and knowledge strategies	Improvement of soil fertility				8, 9, 10-18
	Increase organic matter content of topsoil	19, 20, 21	19, 20, 21	19, 20, 21	19, 20, 21
	Combat wind erosion	25, 26	25, 26	25, 26	22, 23, 24
	Combat water erosion	27, 28, 29	27, 28, 29	27, 28, 29	27, 28, 29
	Reduce leaching losses				31
	Shallow soils		33, 34	33, 34	33, 34
	Dry soils	35	35	35	35
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43	40, 42, 43	40, 42, 43, 44
	Rock-phosphate	45, 46, 47, 48, 49	46, 49	46, 49	45, 47, 48, 49

	Phosphate fertilizers	50, 51, 53		50, 51, 53	50, 51, 53
	NPK-fertilizers	59	59	59	
	Liming, ash	69			69
Mechanisation draught strategies		71, 73	71, 73	71, 73	72, 73
Community strategies	Irrigation				74
Research/extension strategies	Crop response data, crop choice, varieties	81		81	79-81
Government strategies	Erosion control	88	88	88	88

Required inputs for all areas:

- Urea

Specific required inputs for each area:

- Mpwapwa: rock-phosphate, TSP/SSP, NPK, liming materials
- Rocky terrain Mbeya-Mbozi: some rock-phosphate
- Lukosi, lower Mufindi: TSP/SSP, some rock-phosphate, possibly some NPK
- Karatu: rock-phosphate, TSP

Category K3

- Population: low
- Rainfall: medium
- Market orientation: moderate
- Soil conditions: moderate
- Fallow: possible
- Agro-ecological zones: Lw-2c (unit B2l3), Me-4a (units B2d1-4, B2j3)
- Two different areas:
 - Uruwira, Inyonga, Western plateau, Tabora plain
 - Bukombe, Sikonge-Msisi
- Soil fertility management issues: Less scope for fertilizer use, unless economic returns can be expected from cash crops on particular soil types and depending on availability of inputs and transport costs to the nearest market as well as storage costs.
- Likely constraints: drought, acidity, fertility (N, RP, P, K, NPK, manure), leaching, erosion, overgrazing, capping, low organic matter, drainage, workability, soil depth, soil degradation (gully erosion), flooding

Strategy type	IPNM strategy	Numbers for zone Lw-2c (Bukombe, Sikonge-Msisi)	Numbers for zone Me-4a (Uriwira, Inyonga, Western plateau, Tabora plain)
Labour strategies	Shallow soils		1
	Restoration of soil fertility	2, 3, 4	2, 3, 4
	Grazing	6, 7	6, 7
Labour and knowledge	Improvement of soil fertility	8, 9, 10-18	10-18

strategies			
	Increase organic matter content of topsoil	19, 20, 21	19, 20, 21
	Combat wind erosion	25, 26	25, 26
	Combat water erosion	27	27, 28, 29
	Reduce leaching losses	30	
	Shallow soils		33, 34
	Dry soils	35	35
	Flooded soils		37
	Poorly or imperfectly drained soils	38	
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44
	Rock-phosphate	45, 46, 47, 48, 49	45, 46, 47, 48, 49
	Phosphate fertilizers	50, 51, 53	
	Potassium fertilizers	54, 55, 56	
	NPK-fertilizers	58, 59, 60	59
	Special inputs	63	
	Liming, ash	69	69
Mechanisation/draught strategies		72, 73	71, 72, 73
Community strategies	Irrigation	74	
Research/extension strategies	Crop response data, crop choice, varieties	79-82	81
Government strategies	Flood control		87
	Erosion control		88

Required inputs for both areas:

- Urea, rock-phosphate, some NPK, liming materials

Specific required inputs for each area:

- Bukombe, Sikonge-Msisi: TSP/SSP, K₂SO₄, boron

Category K4

- Population: low
- Rainfall: medium
- Market orientation: low to moderate
- Soil conditions: poor
- Fallow: possible
- Agro-ecological zones: Ka-3b (unit B1f), Ka-4c (units B2f1, B2f3, B2t), Me-4b (units B2p1, B2r, B3c1-2, B3h1), Me-5c (units C3a2, C3b, C3c), Sa-1 (unit A2f)
- Four different areas:
 - Songea, sandstone areas (B5h)
 - Eastern and Southern plains (B5)
 - Katumba, Busando, Kigoma lakeshore
 - Mahenge basin, Mkulula valley, wet eastern lowlands, Eastern footslopes
- Soil fertility management issues: Less scope for fertilizer use, unless economic returns can be expected from cash crops on very particular soil types and depending on availability of inputs and transport costs to the nearest market as well as storage costs.

Strategy type	IPNM strategy	Numbers for zone Ka-3b (Nkansi-Kasanga)	Numbers for zone Ka-4c (Katumba Busando, Kigoma lake-shore)	Numbers for zone Me-4b (Mahenge Mkulula)	Numbers for zone Me-5c (EZ, SZ plains (B5))	Numbers for zone Sa-1 (Songea sand-stone)
Labour strategies	Shallow soils			1		1
	Restoration of soil fertility	4	4	2, 3, 4	2, 3, 4	2, 3
	Grazing			6, 7	6, 7	
Labour and knowledge strategies	Improvement of soil fertility		10-18	10-18	10-18	10-18
	Increase organic matter content of topsoil	19	19	19, 20, 21	19, 20, 21	19, 20, 21
	Combat wind erosion			25, 26	25, 26	
	Combat water erosion	27, 29	27, 29	27, 29	27, 29	27, 28, 29
	Shallow soils			33, 34		33, 34
	Dry soils		35	35	35	35
External input strategies	Nitrogen fertilizers	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43, 44	40, 42, 43
	Rock-phosphate	45, 47, 48	45, 47, 48, 49	45, 46, 47, 48, 49	45, 46, 47, 48, 49	46, 49
	Phosphate fertilizers		50, 51, 53			50, 51, 53
	Potassium fertilizers		54, 55, 56			
	NPK-fertilizers		58, 60	59	59	59
	Special inputs	61-66	61-66			
	Liming, ash	69	69	69	69	
Mechanisation/draught strategies			73	72, 73	72, 73	71, 73
Research/extension strategies	Crop response data, crop choice, varieties			81	81	
Government strategies	Erosion control	88	88			88

Required inputs for all areas:

- Urea

Specific required inputs for each area:

- Nkansi-Kasanga: rock-phosphate, liming materials, possibly micro-nutrients
- Katumba, Busando, Kigoma lakeshore: rock-phosphate, TSP/SSP, K_2SO_4 , NPK, possibly micro-nutrients
- Mahenge basin, Mkulula, Eastern and Southern plains: rock-phosphate, liming materials, some NPK
- Songea sandstone areas: TSP/SSP, some rock-phosphate, some NPK

Category K5

- Population: low
- Rainfall: medium
- Market orientation: low
- Soil conditions: moderate
- Fallow: possible
- Agro-ecological zones: La-2 (units C2c1-3), Sa-4 (unit D2i)
- Two different areas:
 - Gumbiro
 - Rukwa, Songwe
- Soil fertility management issues: little scope for fertilizer use, unless economic returns can be expected from cash crops or to keep the soil fertility sustainable.

Strategy type	IPNM strategy	Numbers for zone La-2 (Rukwa, Songwe)	Numbers for zone Sa-4 (Gumbiro)
Labour strategies	Shallow soils	1	
	Restoration of soil fertility	3, 4	2, 3
	Grazing	6, 7	
Labour and knowledge strategies	Improvement of soil fertility		10-18
	Increase organic matter content of topsoil	19	19, 20, 21
	Combat wind erosion	25, 26	
	Combat water erosion	27, 29	
	Shallow soils	33, 34	
	Dry soils	35	35
	Flooded soils	37	
	Poorly or imperfectly drained soils		38
	Sodic or alkaline soils	39	
External input strategies	Nitrogen fertilizers	40, 41, 42, 43	40, 42, 43
	Rock-phosphate	46, 49	46, 49
	Phosphate fertilizers	50, 51, 52, 53	50, 51, 53
	NPK-fertilizers		59
Mechanisation/draught strategies		73	73
Community strategies	Irrigation	75	
Research/extension strategies	Crop response data, crop choice, varieties	81	
Government strategies	Flood control	87	

Required inputs for both areas:

- Urea, TSP/SSP, some rock-phosphate

2. GUIDELINES

In order to use the information given in Vol. IV the following guidelines are given:

- Application of results of chapter 5 (Vol. IV) on IPNM options per agro-ecological zone, including some examples
- Verification needs by NSS
- Guidelines for NSS to become a soil information centre

2.1. Guidelines on how to use the selected IPNM options per agro-ecological zone

The following guidelines are applicable:

- 1. Choose a particular agro-ecological zone or mapping unit
- 2. Identify the zone as described in Vol. IV.
- 3. Verify the information on the agro-ecological zone (Vol. I)
- 4. Verify the information on soils (Vol. II, especially Ch.4)
- 5. Verify soil fertility trial data and crop responses, verify external input options (Vol. IV, table 4-1)
- 6. Verify the farming system and the crops and livestock importance (Vol. III)
- 7. Verify the type of constraints (Vol. IV)
- 8. Verify the IPNM strategies given (Vol. IV)
- 9. Make a list of the abbreviations of IPNM options given in the table of strategies and options for each zone (Vol. IV)
- 10. Identify the particular options from the appendix, Vol. V.
- 11. Verify the usefulness of these options and make modifications if required
- 12. Add new options, if specific circumstances require this addition. In some cases constraints may occur, which were not yet included in the present set of IPNM options
- 13. Describe the list of options in terms clear for further IPNM work with extension staff and groups of farmers.

Four examples are given. These concern the East Usambara (Lushoto) area (selection category A2), Mbozi plateau in Southern Highlands (category B3), Iringa plain in Southern Highlands (category C2) and the Southern hinterland plains (category F2).

2.1.1. Example Lushoto, mapping unit Ald5

- Agro-ecological zone Gn-1b, likely constraints in Vol. I, p. 23.
- Major soils types used for cultivation: 272 and 363, likely constraints Vol. II, p.27+, 38+
- Soil fertility trials and crop response results: not known yet
- Farming system group: 2c2 and farming system maize-bean (2), likely constraints Vol. III, p. 25+, 50+
- Likely constraints: radiation, temperature, drought, erosion, fertility (P-retention?), acidity, soil depth, landslides, leaching (rejected constraints: workability, salinity, sodicity, capping, flooding, soil degradation (gully erosion in dry climates))
- Relevant IPNM strategies identified: 1, 27, 29, 33, 34, 35, 40, 42, 43, 44, 45, 47, 48, 49, 50, 51, 53, 69, 73, 86, 88
- Relevant IPNM options identified:
 - Bukoba: Ma6, Ma7, Co1, Gm1, Gm2, Fe1, Re4, Rw2
 - Sukuma: Rd1, Rd3, K/N1b, K/N1c, K/N4, K/N 5, K/N 6, K/N7, K/N 9, K/N10, K/N11, M/C 4, M/C5, In 1, Ve2

- NZ: Cs4, Cs6, Cs7, Cs9, Fo1, R11, Ma1, Ma6, Fe1, Fe2, Fe3, Fe4
- Additional: A11 (cf. Vol. IV, Table 4-1)

List of selected, combined and adapted IPNM options for Lushoto:

MANURE AND COMPOST:

1. Make compost of all (organic) household refuse with proper shelter and by adding small quantities of bonemeal, ashes, green manure. Apply especially on vegetables and beans (Bukoba option Co 1)
2. Add, per category of soil fertility managers, to be mixed with the manure or compost to be applied to the field:
 - good and medium: (20-50 kg) Minjingu rockphosphate per (ton) of manure directly before application of the manure or compost to the maize and vegetable fields
 - poor: if possible at least some quantity of Minjingu rock phosphate (Sukuma option M/C 5, NZ option Ma6)
3. Apply per soil fertility manager category of farmer: good: (1 ton/ha), medium: (300 kg/ha) and poor: as much as possible manure by spreading and incorporating between the coffee trees every year (Bukoba option Ma 6)
4. For good and medium soil fertility managers: apply (1.75 tons/ha) manure on maize if maize yield is expected to be more than (1500 kg/ha) (Bukoba option Ma 7)
5. Apply, per category of soil fertility managers: good: (3-4 tons/ha), medium: (1-3 tons/ha) and poor: (0.5-1 tons/ha) good quality manure on intercropped maize/bean. Medium and poor managers could also add ashes as much as possible (NZ option Ma 1).
6. Burn residues with (noxious) weeds and use ashes in the compost pit and spread around banana (Bukoba option Re 4)

CROP ROTATION, INTERCROPPING, RELAY CROPPING, GREEN MANURE:

7. Intercropping with legumes, per category of soil fertility managers:
 - good: less relevant, medium: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields
 - poor: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields (Sukuma option In 1).
8. Intercrop maize with a legume (cowpea, bambara nuts, green gram, groundnut, pigeon pea), which can grow during part of the dry season. Protect the legume from grazing during the dry season (Sukuma option K/N 5).
9. Either grow cassava or sweet potato after maize. Intercrop cassava with a legume or (Tephrosia) which can grow during part of the dry season (Sukuma option K/N 6).
10. Interplant (Mucuna) or (Canavalia) four weeks after maize. Incorporate the green manure before planting the next crop or leave as mulch (Bukoba option Gm 1).
11. Plant (Crotalaria) as pure stand and incorporate before planting next maize crop (Bukoba option Gm 2).
12. Plant multi-purpose trees and shrubs along field boundaries and permanent kraal sites (Sukuma option K/N 9).
13. Grow green manure crops as intercrop between maize or cassava or as relay crop after maize and feed the residues to the cattle or add to the compost pit. Let cattle browse from leguminous trees and shrubs (Sukuma option M/C 4).
14. Plant fodder crops (useful species) on field boundaries and on contour bunds (NZ option Fo 1).

SOIL CONSERVATION:

15. On more sloping land ridges of sufficient height along the contour prevents run-off. Incorporate weeds as much as possible, well in advance of planting the next crop (Sukuma option Rd 1).
16. Make contourbunds or large ridges planted with grass or leguminous shrubs along the contour on the steepest slopes (Sukuma option Rd 3, NZ option Cs 4).
17. Establish storm drains to evacuate running water during heavy rain periods in sloping land (NZ option Cs 6).

18. Establish contour bunds on sloping land, and protect them with (perennial) grasses. Plant such grasses also around fields, unless they might become weeds in the fields. Such grasses could also be planted in (gullies) (on sloping land) (NZ option Cs 7).
19. Fill gullies with stones or small dams to reduce speed of running water and to create water basins (NZ option Cs 9).
20. Prevention and prediction of landslide hazard (A11)

SOIL FERTILITY RESTORATION:

21. On exhausted fields after a long period of continuous cultivation once in four years (0.5 tons/ha) of lime and mix as deep as possible in the topsoil during land preparation. Follow with option K/N 1 (Sukuma option K/N 10, Bukoba option A/11) or apply, per category of soil fertility managers:
 - good: (0.5-1 tons/ha) of ((dolomitic) lime) once every four years or increase the manure to (7 tons/ha)
 - medium: (1 bag/ha) of (TSP) or increase the quantity of manure (Sukuma option K/N1c)
22. Apply, per category of soil fertility managers:
 - good and medium: (200 kg/ha)
 - poor: if possible at least some quantity of Minjingu rockphosphate in the furrows during ridge making before planting maize. Mix the rock phosphate with the dry manure just before application and mix as deep as possible in the topsoil during land preparation (Sukuma option K/N 1b).

FERTILISER:

22. If no rock-phosphate is used, apply (1 bag/ha) of (TSP) during ridge making before planting a cash crop in the year following the maize. Try more, up to (3 bags/ha) the next year (Sukuma option K/N 7).
23. For good and medium soil fertility managers: apply (30 g) of (CAN) to young coffee trees (of up to 5 years old) and (60 g) of (CAN) to older coffee trees, to be applied twice a year at the beginning of the short and the long rains (Bukoba option Fe 1) or when mulch is decomposed to some extent and coffee yields are more than (500 kg/ha), use per category of soil fertility managers: good: up (3-4 bags/ha) of (urea) and medium: up to (1-2 bags/ha) of (urea) on coffee in three to six splits every year. Increase these amounts somewhat when mulching heavily (NZ option Fe 3).
24. Apply in two splits per year a quantity of (120 to 150 kg/ha) of (urea) on tea clones K35 and 7/3 and up to (650 kg/ha) on other tea clones (Bukoba option Rw 2).
25. Topdress during the long rainy season maize, depending on the actual rainfall after timely sowing and weeding and when using good quality seed, with, per category of soil fertility managers: - good: (1 to 4 bags/ha), medium: (1-2 bags/ha) of (urea), to be applied one-third at (emergence) and two-third when the maize is at knee height. Try out (one bag/ha) first and observe the increase in maize and/or bean yields. If increase is satisfactory and weather conditions are good, try out more (urea) (NZ option Fe 1) or
26. Apply (1 to 1.5 bags/ha) urea after weeding the maize, when rains are good. Try out up to (1-2 bags/ha), if the rains are good. Make sure that (urea) application is combined with manure application (Sukuma option K/N 4) or
27. Grow maize after the vegetables and apply (1 bag/ha) urea after weeding the maize (Sukuma option Ve 2).
28. For good and medium soil fertility managers: apply (one bag/ha) urea on vegetables like tomato, (cabbage), and (mustard) and (nightshade). For irrigated vegetables (one bag of NPK (20:10:10) could be tried instead of urea (NZ option Fe 2).
29. For good and medium soil fertility managers: use some (urea) and (KCl) on Irish potato (NZ option Fe 4).
30. After years of good production increase the quantities of fertilizers to the maximum, as indicated (Sukuma option K/N 11).
31. Possibly specific fertilizer (e.g. K_2SO_4) for banana might be considered

The specific quantities of inputs have to be verified with crop response and price data.

As Lushoto is densely populated, with a good market orientation, the emphasis in IPNM is on intensification, use of small quantities of inputs, soil and soil fertility conservation measures.

2.1.1.2. Example Mbozi plateau, mapping unit Bld

- Agro-ecological zone Vo-2, likely constraints in Vol. I, p. 66-67.
- Major soils types used for cultivation: 264, 275, 478 and 681, likely constraints Vol. II, p.24-25, 27-29, 51-58, 80-85.
- Soil fertility trials and crop response results: not known yet
- Farming system group: 1d2 and farming system coffee-maize-bean (1), likely constraints Vol. III, p. 11 and 45.
- Likely constraints: radiation, temperature, erosion, fertility (P-retention?), acidity, capping; soils have a tendency to dry out quickly, although the drought risk is low (rejected constraints landslides, leaching, soil depth)
- Relevant IPNM strategies identified: 4, 19, 27, 29, 40, 42, 43, 45, 47, 48, 50, 51, 53, 88
- Relevant IPNM options identified:
 - Bukoba: Ma6, Ma7, Co1, Gm1, Gm2, Fe1, Fe2
 - Sukuma: Rd1, Rd3, M/C4, M/C5, In1, Ve2
 - NZ: Cs4, Cs7, Cs9, Fo1, R11, Fe1, Fe2, Fe3, Fe4, Fe5, Ma1, Ma6

List of selected, combined and adapted IPNM options for Mbozi:

MANURE AND COMPOST:

1. Make compost of all (organic) household refuse with proper shelter and by adding small quantities of bonemeal, ashes, green manure. Apply especially on vegetables and beans (Bukoba option Co 1).
2. Add, per category of soil fertility managers:
 - good and medium: (20-50 kg) Minjingu rockphosphate per (ton) of manure directly before application of the manure or compost to the maize and vegetable fields
 - poor: if possible at least some quantity of Minjingu rock phosphate to be mixed with the manure or compost to be applied to the field (Sukuma option M/C 5, NZ option Ma6)).
3. Apply per soil fertility manager category of farmer: - good: (1 ton/ha), medium: (300 kg/ha) and poor: as much as possible manure by spreading and incorporating between the coffee trees every year (Bukoba option Ma 6).
4. For good and medium soil fertility managers: apply (1.75 tons/ha) manure on maize, if the maize yield is expected to be more than (1500 kg/ha) (Bukoba option Ma 7).
5. Apply, per category of soil fertility managers: - good: (3-4 tons/ha), medium: (1-3 tons/ha) and poor: (0.5-1 tons/ha) good quality manure on maize/bean. Medium and poor managers could also add ashes as much as possible (NZ option Ma 1).

FODDER, INTERCROPPING, RELAY CROPPING, GREEN MANURE:

6. Grow green manure crops as intercrop between maize or cassava or as relay crop after maize and feed the residues to the cattle or add to the compost pit. Let cattle browse from leguminous trees and shrubs (Sukuma option M/C 4).
7. Intercropping with legumes, per category of soil fertility managers: - good: less relevant, medium: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields and poor: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields (Sukuma option In 1).

8. Plant (useful species) on field boundaries and on contour bunds (NZ option Fo 1).
9. Plant (green manure species, e.g. semi-perennial pigeon pea, lablab, jackbean, mucuna) after establishment of the main crop, in order to create cover or mulch during part of the dry season (NZ option R1 1).
10. Interplant (Mucuna) or (Canavalia) four weeks after maize. Incorporate the green manure before planting the next crop or leave as mulch (Bukoba option Gm 1).
11. Plant (Crotalaria) as pure stand and incorporate before planting next maize crop (Bukoba option Gm 2).

SOIL CONSERVATION:

12. Make ridges or even tied-ridges on sloping fields (NZ option Cs 4, Sukuma option Rd1).
13. Establish contour bunds or large ridges on sloping land, and protect them with (perennial) grasses or leguminous shrubs. Plant such grasses also around fields, unless they might become weeds in the fields. Such grasses could also be planted in (gullies) (on sloping land) (NZ option Cs 7, Sukuma option Rd3).
14. Fill gullies with stones or small dams to reduce speed of running water (NZ option Cs 9).

SOIL FERTILITY RESTORATION AFTER ACIDIFICATION RESULTING AFTER LONG PERIOD OF CULTIVATION OR INTENSIVE N-FERTILIZER USE:

15. On poor growing spots or fields, per category of soil fertility manager:
 - Good: Together with a proper mulch, incorporate small quantities of ash or (dolomitic lime) and repeat until growth of crops become normal.
 - Medium and poor: Use ashes in small quantities and repeat until growth of crops becomes normal (Bukoba option A/1 1) or
16. Apply, by mixing as deep as possible in the topsoil during land preparation, per category of soil fertility managers:
 - good: (0.5-1 tons/ha) of ((dolomitic) lime) once every four years or increase the manure to (7 tons/ha)
 - medium: (1 bag/ha) of (TSP) or increase the quantity of manure (Sukuma option K/N 1c and 10).
17. Apply, per category of soil fertility managers: - good and medium: (200 kg/ha) and poor: if possible at least some quantity of Minjingu rockphosphate in the furrows during ridge making before planting maize. Mix the rock phosphate with the dry manure just before application and mix as deep as possible in the topsoil during land preparation (Sukuma option K/N 1b).

FERTILISER:

18. . Topdress maize, depending on the actual rainfall after timely sowing and weeding and when using good quality seed, with, per category of soil fertility managers:
 - good: (1 to 4 bags/ha), medium: (1-2 bags/ha) of (urea), to be applied one-third at (emergence) and two-third when the maize is at knee height. Try out (one bag/ha) first and observe the increase in maize and/or bean yields. If increase is satisfactory and weather conditions are good, try out more (urea) (NZ option Fe 1) or
19. Apply (1 to 1.5 bags/ha) urea after weeding the maize, when rains are good. Try out up to (1-2 bags/ha), if the rains are good. Make sure that (urea) application is combined with manure application (Sukuma option K/N 4) or
20. Grow maize after vegetables and apply (1 bag/ha) urea after weeding the maize (Sukuma option Ve 2).
21. For good and medium soil fertility managers: apply (one bag/ha) urea on vegetables like tomato, (cabbage), and (mustard) and (nightshade) (NZ option Fe 2).
22. When mulch is decomposed to some extent and coffee yields are more than (500 kg/ha), use per category of soil fertility managers: good: up to (3-4 bags/ha) of (urea) and medium: up to (1-2 bags/ha) of (urea) on coffee in three to six splits every year. Increase these amounts somewhat when mulching heavily (NZ option Fe 3) or
23. For good and medium soil fertility managers: apply (30 g) of (CAN) to young coffee trees (of up to 5 years old) and (60 g) of (CAN) to older

- coffee trees, to be applied twice a year at the beginning of the rains (Bukoba option Fe 1).
24. For good and medium soil fertility managers: use some (urea) and (KCl) on Irish potato (NZ option Fe 4).
 25. For good and medium soil fertility managers: try out (1 bag/ha) of (urea) on wheat as topdressing, if weather conditions are good. If successful, try out up to (2 bags/ha) of urea (NZ option Fe 5).
 26. For good soil fertility managers: apply (x kg/ha) of Multi-K to banana in splits (Bukoba option Fe 2).

The specific quantities of inputs have to be verified with crop response and price data.

As Mbozi is densely populated, with a relatively low market orientation, the emphasis in IPNM is on intensification, use of inputs in relation to labour returns, soil and soil fertility conservation measures.

2.1.3. Example Iringa, mapping unit D1b1

- Agro-ecological zone Gn-6a, likely constraints in Vol. I, p. 26.
- Major soils types used for cultivation: 111, 237, 272, 473 and 501, likely constraints Vol. II, p. 7-10, 19-21, 27-28, 52-56 and 61-62.
- Soil fertility trials and crop response results: not known yet
- Farming system group: 2c2 and farming system maize-bean (4a) and sorghum-fingermillet (1), likely constraints Vol. III, p. 25, 51 and 73
- Likely constraints: drought, fertility, low organic matter, capping, soil depth, soil degradation (gully erosion), overgrazing (rejected constraints salinity, acidity)
- Relevant IPNM strategies identified: 1, 4, 6, 7, 19, 25, 26, 27, 29, 33, 34, 35, 40, 42, 43, 49, 50, 51, 53, 73, 75, 81
- Relevant IPNM options identified:
 - Bukoba: Gm1, Gm2, Ma7, Co1
 - Sukuma: Rd1, Rd2, Rd3, K/N1c, K/N4, K/N5, K/N6, K/N7, K/N9, K/N11, M/C4, In1, In2, Re5, Ve2
 - NZ: Ma1, Ma6, Cs1, Cs2, Cs4, Cs6, Cs7, Cs8, Cs9, Cs10, Fo1, R11, Fe1, Fe2
 - Additional: A1 (Vol.IV., Table 4-1)

List of selected, combined and adapted IPNM options for Iringa:

MANURE AND COMPOST:

1. Apply, per category of soil fertility managers: - good: (3-4 tons/ha), medium: (1-3 tons/ha) and poor: (0.5-1 tons/ha) good quality manure on maize/bean. Medium and poor managers could also add ashes as much as possible (NZ option Ma 1) or
2. For good and medium soil fertility managers: apply (1.75 tons/ha) manure on maize if the maize yield is expected to be more than (1500 kg/ha) (Bukoba option Ma 7).
3. For medium soil fertility managers: enrich the manure just before application with a small quantity of (rockphosphate) or (TSP) (NZ option Ma 6).
4. Make compost of all (organic) household refuse with proper shelter and by adding small quantities of bonemeal, ashes, green manure. Apply especially on vegetables and beans (Bukoba option Co 1).
5. If crop residues are being grazed by cattle, that are not owned by the farmer, barter for manure, transport or ploughing the next season (Sukuma option Re 5).

INTERCROPPING, GREEN MANURE, RELAY CROPPING, FODDER:

6. Interplant (*Mucuna*) or (*Canavalia*) four weeks after maize. Incorporate the green manure before planting the next crop or leave as mulch (Bukoba option Gm 1).
7. Plant (*Crotalaria*) as pure stand and incorporate before planting next maize crop (Bukoba option Gm 2).
8. Grow green manure crops as intercrop between maize or cassava or as relay crop after maize and feed the residues to the cattle or add to the compost pit. Let cattle browse from leguminous trees and shrubs (Sukuma option M/C 4).
9. Intercropping with legumes, per category of soil fertility managers: - good: less relevant, medium: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields and poor: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields (Sukuma option In 1).
10. Relay cropping of legumes as much as possible by planting the legume during the rainy season in between another crop and to leave the legume to continue to cover the field after the harvest of the main crop (Sukuma option In 2).
11. Intercrop maize with a legume (cowpea, bambara nuts, green gram, groundnut, pigeon pea), which can grow during part of the dry season. Protect the legume from grazing during the dry season (Sukuma option K/N 5).
12. Either grow cassava or sweet potato after maize. Intercrop cassava with a legume or (*Tephrosia*) which can grow during part of the dry season (Sukuma option K/N 6).
13. Plant multi-purpose trees and shrubs along field boundaries and permanent kraal sites (Sukuma option K/N 9).
14. Plant (green manure species, e.g. semi-perennial pigeon pea, lablab, jackbean, mucuna) after establishment of the main crop, in order to create cover or mulch during part of the dry season (NZ option Rl 1).
15. Plant fodder crops (useful species) on field boundaries and on contour bunds (NZ option Fo 1).

SOIL FERTILITY RESTORATION:

16. Apply, per category of soil fertility managers: - good: (0.5-1 tons/ha) of ((dolomitic) lime) once every four years or increase the manure to (7 tons/ha) and medium: (1 bag/ha) of (TSP) or increase the quantity of manure (Sukuma option K/N 1c).

SOIL FERTILITY CONSERVATION:

17. Plant (multi-purpose trees) at sites with (dominant) wind during the dry periods, and also as hedges, woodlots, life fences as well as around the homestead (NZ option Cs 1).
18. On lowland sites special drought-resistant and goat-resistant and sometimes salt-resistant trees [to be named] should be selected. Make small depressions on lowland sites to be planted with perennial grasses, shrubs or trees. Possibly use some manure (NZ option Cs 2).
19. Make ridges or even tied-ridges on sloping fields (NZ option Cs 4).
20. Make contourbunds or large ridges planted with grass or leguminous shrubs along the contour on the steepest slopes (Sukuma option Rd 3).
21. On more sloping land make ridges of sufficient height along the contour to prevent run-off. Incorporate weeds as much as possible, well in advance of planting the next crop (Sukuma option Rd 1).
22. Establish (storm drains) and (water basins) to (evacuate) running water during heavy rain periods in sloping land (NZ option Cs 6).
23. Establish contour bunds on sloping land, and protect them with (perennial) grasses. Plant such grasses also around fields, unless they might become weeds in the fields. Such grasses could also be planted in (gullies) (NZ option Cs 7).
24. For good soil fertility managers: (dry plough or harrow) to shallow depth after grazing to conserve moisture (NZ option Cs 8).
25. Fill gullies with stones or small dams to reduce speed of running water and to create water basins (NZ option Cs 9).
26. For medium and poor soil fertility managers: prevent grazing by livestock from other farmers by planting (life fences) of drought tolerant, thorny, goat-resistant shrubs (NZ option Cs 10).

DROUGHT:

27. In drier areas or during drier rainy seasons on upper slope positions, try out, per category of soil fertility managers:
- good and medium: tied ridges by plough or hand hoe
 - poor: tied ridges by hand hoe if possible (Sukuma option Rd 2).
28. Try out water harvesting methods (A1)

FERTILISER:

29. Topdress maize/beans, depending on the actual rainfall after timely sowing and weeding and when using good quality seed, with, per category of soil fertility managers: - good: (1 to 4 bags/ha), medium: (1-2 bags/ha) of (urea), to be applied one-third at (emergence) and two-third when the maize is at knee height. Try out (one bag/ha) first and observe the increase in maize and/or bean yields. If increase is satisfactory and weather conditions are good, try out more (urea) (NZ option Fe 1) or
30. Apply (1 to 1.5 bags/ha) urea after weeding the maize, when rains are good. Try out up to (2 bags/ha), if the rains are good. Make sure that (urea) application is combined with manure application (Sukuma option K/N 4).
31. For good and medium soil fertility managers: apply (one bag/ha) urea on vegetables like tomato, (cabbage), and (mustard) and (nightshade). For irrigated vegetables (one bag of NPK (20:10:10) could be tried instead of urea (NZ option Fe 2).
32. Apply (1 bag/ha) of (TSP) during ridge making before planting a cash crop (sunflower?) in the year following the maize. Try more, up to (3 bags/ha) the next year (Sukuma option K/N 7).
33. Grow maize or cotton after the vegetables and apply (1 bag/ha) urea after weeding the maize or cotton (Sukuma option Ve 2).
34. After years of good production increase the quantities of fertilizers to the maximum, as indicated (Sukuma option K/N 11).

The specific quantities of inputs have to be verified with crop response and price data.

As the Iringa plain is moderately populated, with a moderate market orientation, the emphasis in IPNM is on appropriate use of inputs in relation to actual rainfall and nutrient deficiencies in combination with good quality seed and agronomic practices.

2.1.4. Example Southern hinterland plains, mapping unit B311

- Agro-ecological zone Co-2b, likely constraints in Vol. I, p. 18.
- Major soils types used for cultivation: 331, 451, 523, 643 and 676, likely constraints Vol. II, p.31-33, 51-53, 61-66, 70-74 and 80-83.
- Soil fertility trials and crop response results: not known yet
- Farming system group: 2j1 and farming system cashew (1), likely constraints Vol. III, p. 31 and 40.
- Likely constraints: drought, workability, acidity, fertility, low organic matter (rejected constraints flooding, drainage, salinity, sodicity, soil degradation (gully erosion))
- Relevant IPNM strategies identified: 2, 3, 4, 19, 20, 21, 25, 26, 35, 40, 42, 43, 44, 46, 49, 59, 69, 72, 73
- Relevant IPNM options identified:
 - Bukoba: Co1, A/11, Gm1, Gm2, Ma7
 - Sukuma: Rd2, K/N1a, K/N1b, K/N1c, K/N2, K/N4, K/N5, K/N6, K/N7, K/N9, K/N10, K/N11, Rc1, Rc2, Rc3, Rc5, Rc6, Rc7, Rc8, M/C4, M/C5, M/C6, Re1, In1, In2, Mb1, Ve1, Ve2
 - NZ: Ma1, Ma5, Ma6, Cs1, Cs2, Cs4, Cs8, Cs10, R11, M/C2, Fe1, Fe2, Fo1
 - Additional: A1, A2, A14

List of selected, combined and adapted IPNM options for Southern hinterland plains:

MANURE AND COMPOST:

1. Grow green manure crops as intercrop between maize or cassava or as relay crop after maize and feed the residues to the cattle or add to the compost pit. Let cattle browse from leguminous trees and shrubs (Sukuma option M/C 4).
2. Apply once in three to four years before planting maize, per category of soil fertility managers: - good: (5 tons/ha), medium: (2.5 tons/ha) and preferably more and poor: as much as possible manure of good quality (Sukuma option K/N 1a) or
3. Apply, per category of soil fertility managers: - good: (3-4 tons/ha), medium: (1-3 tons/ha) and poor: (0.5-1 tons/ha) good quality manure on maize. Medium and poor managers could also add ashes as much as possible (NZ option Ma 1).
4. For good and medium soil fertility managers: apply (1.75 tons/ha) manure on maize, if the maize yield is expected to be more than (1500 kg/ha) (Bukoba option Ma 7).
5. Use manure especially at (high-response) crops (like cassava, sweet potato) (NZ option Ma 5).
6. Add, per category of soil fertility managers: - good and medium: (20-50 kg) Minjingu rockphosphate per (ton) of manure directly before application of the manure or compost to the maize and vegetable fields and poor: if possible at least some quantity of Minjingu rock phosphate to be mixed with the manure or compost to be applied to the field (Sukuma option M/C 5) or
7. For medium soil fertility managers: enrich the manure just before application with a small quantity of (rockphosphate) or (TSP) (NZ option Ma 6).
8. For poor soil fertility managers, instead of manure, use compost of good quality on the maize and vegetables fields (Sukuma option M/C 6) or
9. Make compost of all (organic) household refuse with proper shelter and by adding small quantities of bonemeal, ashes, green manure. Apply especially on vegetables and beans (Bukoba option Co 1) or
10. Use a good quantity of good quality manure or compost to the vegetables as possible (NZ option M/C 2).
11. Apply some manure on Mbuga/Vertisol areas if possible to maize or other cash crop (Sukuma option Mb 1).

INTERCROPPING, GREEN MANURE, RESIDUE, FODDER, RELAY CROPPING:

12. Intercropping with legumes, per category of soil fertility managers: - good: less relevant, medium: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields and poor: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields (Sukuma option In 1).
13. Intercrop maize with a legume (cowpea, bambara nuts, green gram, groundnut, pigeon pea), which can grow during part of the dry season. Protect the legume from grazing during the dry season (Sukuma option K/N 5).
14. Either grow cassava or sweet potato after maize. Intercrop cassava with a legume or (Tephrosia) which can grow during part of the dry season (Sukuma option K/N 6).
15. Plant multi-purpose trees and shrubs along field boundaries and permanent kraal sites (Sukuma option K/N 9).
16. Interplant (Mucuna) or (Canavalia) four weeks after maize. Incorporate the green manure before planting the next crop or leave as mulch (Bukoba option Gm 1).
17. Plant (Crotalaria) as pure stand and incorporate before planting next maize crop (Bukoba option Gm 2).
18. If the topsoil of sandy soils is very light coloured, do not incorporate more than (2 tons/ha) of straw. Use the remainder of the straw as bedding in the kraal (Sukuma option Re 1).
19. Plant fodder crops (useful species) on field boundaries and on contour bunds (NZ option Fo 1).

20. Relay cropping of legumes as much as possible by planting the legume during the rainy season in between another crop and to leave the legume to continue to cover the field after the harvest of the main crop (Sukuma option In 2) or
21. Plant (green manure species, e.g. semi-perennial pigeon pea, lablab, jackbean, mucuna) after establishment of the main crop, in order to create cover or mulch during part of the dry season (NZ option R1 1).

RICE OPTIONS:

22. Plant leguminous trees in neighbourhood of rice fields and apply the leaves to the rice fields in the first month after transplanting or the first eight weeks after seeding. In this way the quantity of urea can be reduced (Sukuma option Rc 5).
23. Grow sunflower, (green) maize, sorghum or chickpeas if rains stay out (Sukuma option Rc 6).
24. For good and medium soil fertility managers, apply, if rice yields seems to be decreasing, any quantity of manure in seasons when no rice is grown and incorporate the rice straw (Sukuma option Rc 8).

SOIL FERTILITY RESTORATION:

25. On poor growing spots or fields, per category of soil fertility manager:
 - Good: Together with a proper mulch, incorporate small quantities of ash or (dolomitic lime) and repeat until growth of crops become normal.
 - Medium and poor: Use ashes in small quantities and repeat until growth of crops becomes normal (Bukoba option A/1 1) or
26. Apply, per category of soil fertility managers: - good and medium: (200 kg/ha) and poor: if possible at least some quantity of Minjingu rockphosphate in the furrows during ridge making before planting maize. Mix the rock phosphate with the dry manure just before application and mix as deep as possible in the topsoil during land preparation (Sukuma option K/N 1b) or
27. Apply, per category of soil fertility managers: - good: (0.5-1 tons/ha) of ((dolomitic) lime) once every four years or increase the manure to (7 tons/ha) and medium: (1 bag/ha) of (TSP) or increase the quantity of manure (Sukuma option K/N 1c and 10).
28. For good soil fertility managers, apply (1 bag/ha) of K_2SO_4 in the furrow before planting maize (Sukuma option K/N 2) or rice during land preparation (Sukuma option Rc 2).

SOIL FERTILITY CONSERVATION:

29. Plant (multi-purpose trees) at sites with (dominant) wind during the dry periods, and also as hedges, woodlots, life fences as well as around the homestead (NZ option Cs 1).
30. On lowland sites special drought-resistant and goat-resistant and sometimes salt-resistant trees [to be named] should be selected. Make small depressions on lowland sites to be planted with perennial grasses, shrubs or trees. Possibly use some manure (NZ option Cs 2).
31. For good soil fertility managers: (dry plough or harrow) to shallow depth after grazing to conserve moisture (NZ option Cs 8).
32. For medium and poor soil fertility managers: prevent grazing by livestock from other farmers by planting (life fences) of drought tolerant, thorny, goat-resistant shrubs (NZ option Cs 10).
33. In drier areas or during drier rainy seasons on upper slope positions, try out, per category of soil fertility managers: - good and medium: tied ridges by plough or hand hoe and poor: tied ridges by hand hoe if possible (Sukuma option Rd 2, NZ option Cs4).

FERTILISER:

34. Topdress during maize, depending on the actual rainfall after timely sowing and weeding and when using good quality seed, with, per category of soil fertility managers: - good: (1 to 4 bags/ha), medium: (1-2 bags/ha) of (urea), to be applied one-third at (emergence) and two-third when the maize is at knee height. Try out (one bag/ha) first and observe the increase in maize and/or bean yields. If increase is satisfactory and weather conditions are good, try out more (urea) (NZ option Fe 1) or
35. Apply (1 to 1.5 bags/ha) urea after weeding the maize, when rains are good. Try out up to (2 bags/ha), if the rains are good. Make sure that

- (urea) application is combined with manure application (Sukuma option K/N 4).
36. For good and medium soil fertility managers: apply (one bag/ha) urea on vegetables like tomato, (cabbage), and (mustard) and (nightshade). For irrigated vegetables (one bag of NPK (20:10:10) could be tried instead of urea (NZ option Fe 2) or
 37. Apply, per category of soil fertility managers: - good: (5 tons/ha) of manure of good quality and (1 bag/ha) of K_2SO_4 or NPK (20:10:10) and medium and poor: any quantity of manure or compost of good quality (Sukuma option Ve 1).
 38. Apply (1 bag/ha) of (TSP) during ridge making before planting a cash crop in the year following the maize. Try more, up to (3 bags/ha) the next year (Sukuma option K/N 7).
 39. After years of good production increase the quantities of fertilizers to the maximum, as indicated (Sukuma option K/N 11, Rc 7).
 40. Grow maize or a cash crop after the vegetables and apply (1 bag/ha) urea after weeding the maize or the cash crop (Sukuma option Ve 2).
 41. For good soil fertility managers, when rice yields were disappointing during the last years, apply (1 bag/ha) of NPK (20:10:10) during land preparation and planting of the next crop of rice (Sukuma option Rc 1).
 42. When the varieties rangi mbili, lungunguma or super are used, apply per category of soil fertility managers: - good and medium: (1 bag/ha) of urea (try out up to (4 bags/ha) of urea the next year) and poor: any quantity of (urea) directly after or during weeding (Sukuma option Rc 3).

The specific quantities of inputs have to be verified with crop response and price data.

As the Southern hinterland plains are moderately populated, with a market orientation, the emphasis in IPNM is on intensification with manure and rock phosphate, use of inputs only on cash crops for which transport is available.

2.2. Verification guidelines

Core activities of NSS should include the organization and verification of the following data:

- The agro-ecological and farming system mapping by sending these parts of the maps, including legend to the zonal stations to corrections and additions
- Input the soil profile descriptions and analytical data into the SOTER database. Identify the common number of soil types as given in Vol. II. Use the output of profile descriptions to verify the consistence of each soil type. In case a soil type has sufficient profile descriptions, form a fixed soil type by describing the range of characteristics, a Swahili name to replace the number as well any information on soil management. Make sure criteria why one soil type is different from any other, is well established in a classification system. Make international correlation possible by classifying the soil type by FAO/UNESCO and possible Soil Taxonomy.
- Verify the farming system per mapping unit or land use/farming system group per agro-ecological zone by comparison with the farming system zonation maps.
- Verify table 4-1 in Vol. IV by working out crop responses of N, P and K fertilizers, with or without combination with organic materials like manure. Specify the input need for particular crops per mapping unit of agro-ecological zone.

2.3. Guidelines for future tasks to become a soil information centre

The following activities are advised:

- 1. Put all available data into a general database linked with GIS.
- 2. Provide zonal stations and other government institutions with available mapping material including legend
- 3. Provide these institutions with examples of interpretations used elsewhere.
- 4. Make proposals to districts for which sufficient information is available.
- 5. Prepare a brochure explaining the capacity of interpretations possible with the database (IPNM, suitability, crop responses, soil constraints, soil management issues, hazards, input supply needs)
- 6. Prepare for particular areas or districts or zones where specific training needs and specific soil research needs have been found necessary. Propose funding of such activities in combination with institutions like SUA, zonal stations and coordinate these activities. Use international networks and internet to provide existing.

Annex 1. Database

7 pages

Annex 2. Tentative classification of soil families

The present list of soil types is ordered according to soil depth, soil drainage, degree of leaching, soil texture and FAO/UNESCO units

Numbers refer to soil families that can be subdivided in more detailed soil series. The FAO/UNESCO legend/classification is used tentatively (requires verification). Main locations of occurrence are given in parentheses.

The present list can be used to identify the soil family number in addition to the identification of the particular agro-ecological zone for which the relevant soil number are available.

At the end an overview of the soil types as grouped by way of agro-ecological zone, soil group and farming system group is presented in order to show the sequence of soil types appearing in a particular setting or ecosystem.

Important soil types indicated in bold. There are presently 138 important and 43 less important soil families. Some soil types (42 in total) have been combined at the family level; they could be used for separation at soil series level.

2.1. List of soil types

Shallow depth (< 50 cm) to rock (not including hardpan):

- Very shallow depth (< 25 cm):
 - On volcanic ash (Phaeozem or Vitric Andosol) **102** (Northern)
 - On volcanic ash and basalt (Humic Andosol) 103 (Rungwe/Mbeya)
 - On volcanic ash (Andosol) 104 (Southern Highlands, Serengeti)
 - On volcanic ash (Andosol) 105 (Tarime, Monduli)
 - On sandstone (Lithosol):
 - **106** (Kagera, Kigoma, Southern Highlands)
 - **107** (Eastern, Southern)
 - **110** (SE Songea)
 - 114 (Kigoma)
 - On quartzite/ironstone (Lithosol):
 - **108** (Kagera, Kigoma)
 - **109** (Rukwa)
 - On gneiss or granite (Lithosol) **111** (widespread)
 - On limestone, basalt or argillaceous sandstone 113 (Kigoma)
 - On basalt or on schist, phyllite or granite (Lithosol) **115** (Kagera, Kigoma, Southern Highlands)
- Shallow depth (25-50 cm):
 - On granite or gneiss (Phaeozem/Calcisol) **131** (Northern, Lake zone)
 - On volcanic ash:
 - 132 (Phaeozem?) (Northern)
 - **133** Humic Andosol (Mbeya, Rungwe, Njombe)
 - **142** Vitric Andosol (Northern)
 - On (coral) limestone **144** (Zanzibar, Pemba, Mafia)
 - On gneiss (Phaeozem/Calcisol?) **146** (Eastern, Southern Highlands)

Deeper soils (> 50 cm) or shallow to hardpan:

- **Well or occasionally moderately well drained soils:**
 - *Fluvisols:*
 - On floodplains:
 - **201** (Rufiji)
 - **203** (Kagera, Mara)
 - **204** (Southern Highlands))
 - On alluvial plains in subsidence basins **205** (Kilombero)
 - On lacustrine plains **206** (Kyela)
 - On intramontane plains **208** (Matengo highlands)
 - In granite and lava valleys **209** (Tarime highlands)
 - In valleys on metamorphic rocks **210** Lake, Western, Southern Highlands)
 - Soils with a relatively higher organic matter content and usually somewhat silty with high base saturation (relatively fertile soils):
 - *Phaeozems or Cambisols:*
 - On more recent volcanic ash, Meru and younger volcanoes (Luvic Phaeozem) **231** (Northern)
 - On older volcanic ash, Kilimanjaro, west Serengeti (Luvic Phaeozem) **232** (Northern, Lake zone)
 - On limestone or marl (Phaeozem/Cambisol) **236** (Southern, Eastern)
 - On gneiss (Phaeozem/Cambisol) **237** (Eastern)
 - On older alluvial deposits (Luvic Phaeozem) **238** (Lake, Northern)
 - On old alluvial/colluvial plains (Phaeozem/Cambisol) **239** (Central, Lake)
 - Mollic Solonetz on volcanic ash **251** (Northern))
 - *Andosols:*
 - More weathered Humic or Mollic Andosol **261a** (Mbeya, Rungwe, Njombe)
 - Immature Vitric Andosol on older volcanic ash **261b** (Northern)
 - Vitric Andosol on more recent volcanic ash **262** (Northern)
 - Humic or Mollic Andosol **264** (Mbozi plateau)
 - Humic or Mollic Andosol **265** (Mbeya stepped plain)
 - *Niti/Nitrosols:*
 - On volcanic ash (Humic Nitisol) **271** (Northern)
 - On granite or gneiss without volcanic ash influence (Humic Nitisol) **272** (Eastern, Southern Highlands, Pare mountains)
 - On gneiss and old volcanic rocks (Humic Nitisol) **273** (Tarime highlands)
 - On gneiss without volcanic ash influence **274** (Dissected Chunya plain)
 - On gneiss with influence of volcanic ash (Humic Nitisol) **275** (Rungwe, Mbeya, Njombe)
 - On basalt or argillaceous sandstone (Humic Nitisol) **276** (Kigoma)

- Soils with lower organic matter content and base saturation of more than 25 % (?) (moderately leached) (moderately fertile soils):
 - *Sandy soils:*
 - On coastal sands (Regosol) 301 (Eastern, Southern, Zanzibar, Pemba, Mafia)
 - On volcanic sand dunes (Regosol) 311 (Northern)
 - *Sandy Nitosols:*
 - On volcanic ash (Eutric Nitosol) **321** (Northern)
 - On gneiss at high altitudes (Eutric Nitosol) 322 (Eastern Mbulu)
 - *Sandy Cambisols, Luvisols or Acrisols:*
 - On coastal plains **331** (Western Zanzibar, Pemba)
 - On alluvial plains **332** (Eastern)
 - On coastal plain 333 (Eastern Zanzibar, Pemba, Mafia)
 - On coastal sand cover **334** (Eastern, Southern)
 - On metamorphic rocks in higher rainfall area (A-D climatic zones)(Ferralic Cambisol or other) **335a** (widespread)
 - On metamorphic rocks in dry areas (E-climatic zones) **335b** (sandy Luvisol or Ferralic Cambisol)(Northern, Central, Southern Highlands)
 - On granite or gneiss **336** (Lake, Western, Central)
 - On limestone and basalt **337** (Kigoma)
 - On gneiss (sandy Luvisol) **338** (Central, Southern Highlands, Eastern, pare mountains)
 - On schist and granite (Ferralic Cambisol) **339** (Southern Highlands, Western, Lake)
 - On sandstone (Ferralic Cambisol) **340** (Southern, Southern Highlands, Eastern)
 - On sandstone **341** (Kagera, Kigoma, Southern Highlands)
 - On lacustrine or alluvial deposits, can be salty/sodic **343** (Southern highlands, Central, Northern)
 - *Loamy and clayey soils:*
 - *Ferralsols:*
 - Clayey Ferralsols (nos. 361-368 and 391 may have lower base saturation and then belong to the strongly leached soils, see 450-480)
 - On lavas and granite (Rhodic Ferralsol) **361** (Tarime highlands)
 - On gneiss (Rhodic Ferralsol) **362** (Southern Highlands, Eastern, Northern, Central, Southern)
 - On basic metamorphic rocks (Rhodic? Ferralsol) **364** (Southern Highlands, Kigoma, Kagera)
 - On phyllite **365** (Kigoma, Karagwe)
 - On schist and granite **366** (Kagera, Kigoma)
 - On argillaceous sandstone or basalt **367** (Kigoma)
 - On sandstone or shale **368** (Kagera, Kigoma, Southern Highlands)
 - On basic metamorphic rocks (better structured Rhodic Ferralsol (Nduha)) **381** (Lake, Western, Central, Southern Highlands)
 - On Pleistocene cover over basic metamorphic rocks (better structured Ferralsol) **382** (Central, Western)
 - Loamy Ferralsols on sandstone 391 (Kagera, Kigoma, Southern highlands)

- *Luvi/Acri/Cambisols*:
 - On coastal plains (reddish loamy (?) Chromic Luvisol) **401** (Eastern Zanzibar, Pemba, Mafia)
 - On lavas and granite (clayey soils) **411** (Tarime highlands)
 - On gneiss (clayey soils) **412** (Southern Highlands, Eastern, Northern, Central, Southern)
 - On alluvial complexes (clayey soils) **414** (Rukwa, Songwe)
 - On granite or gneiss (loamy soils) **421** (widespread)
 - On schist or granite (loamy soils) **422** (Kate-Mwazye, Nkungwe in Southern Highlands)
 - On granite or gneiss (loamy soils) **423** (Lake, Western, Central)
 - On sandstone (loamy soils) **424** (Nkansi-Kasanga in Southern highlands)
 - On alluvial or lacustrine sediments (loamy soils) **425** (dry Southern Highlands)
- Strongly leached, older soils (base saturation less than 25 (?) % within x cm depth) (Paleosols, Acrisols, Ferralsols (?), Arenosols):
 - *Arenosols*, often bleached and well to moderately well drained:
 - Arenosols without a clayey (less than x % clay within 50 cm depth) subsoil:
 - On granite or gneiss **501** (widespread, especially in Southern Highlands, Western and Lake)
 - On colluvial or alluvial sediments **502** (Lake, Western)
 - On gneiss **503** (Southern, Eastern)
 - On schist and granite **504** (Kate-Mwazye and Nkungwa in Southern highlands)
 - On limestone or basalt **505** (Kigoma lowlands)
 - On sandstone **506** (Kigoma, Kagera, Southern highlands)
 - On alluvial or lacustrine sediments **507** (Ruaha valley in dry Southern highlands, Central, Northern)
 - On alluvial or lacustrine sediments **508** (Irrigated/flooded area in Central)
 - On alluvial and lacustrine sediments **509** (dry Southern Highlands)
 - Arenosols with a more clayey subsoil (more than x % clay within 50 cm depth):
 - On old alluvium **521** (Eastern alluvial plains)
 - On coastal limestone and marl **522** (Eastern Zanzibar, Pemba, Mafia)
 - On coastal sand cover on coastal plains **523** (eastern Zanzibar, Pemba, Mafia, Eastern, Southern coastal plains)
 - On coastal sand cover or on sediments derived from sandstone, limestone or shale **524** (Eastern, Southern hinterland plains)
 - On Karroo sandstone and shale **527** (Southern, Southern Highland (Ruvumu))

- *Sandy to loamy Paleosols:*
 - On Neogene sediments capped by ironstone **451** (Eastern, Southern hinterland plains)
 - On metamorphic rocks possibly with a coastal sand cover **452** (Eastern, Southern inland plains)
 - On continental deposits (sandy to loamy Acrisol) **454** (Central, Western)
 - On various alluvial and non-alluvial sediments **455** (Ruaha valley in Southern Highlands, Central, Northern)
- *Loamy to clayey Paleosols* (often in semi-arid environments):
 - On metamorphic rocks **461** (Southern Highlands, Eastern, Northern, Central, Lake)
 - On old lacustrine sediments **462** (Lake, Northern, Western)
- *Loamy to clayey Ferralsol/Acrisols:*
 - On Neogene or Jurassic sandstone, shale and limestone **471** (Eastern, Southern hinterland plains with a coastal sand cover)
 - On metamorphic rocks or granite **473** (widespread)
 - On limestone, basalt or argillaceous sandstone **474** (Kigoma lakeshore)
 - On schist and granite **475** (Kate-Mwazy, Nkungwe in Southern Highlands (Rukwa))
 - On metamorphic rocks **476** (Eastern, Southern inland plains)
 - On sandstone **477** (Southern Highlands, Western, Lake)
 - On granite or gneiss and volcanic ash (Ferric Acrisol) **478** (Mbozi)
 - On argillaceous sandstone **479** (Kigoma highlands)
- **Moderately well to imperfectly drained soils** (possibly including some Arenosols (see nrs. 501-527 as well as some of the Hardpan soils (nrs. 601-611), possibly also some Gleysols or Gleyic subgroups (nrs. 670-693)):
 - *Vertisols* without prolonged waterlogging (occurring on slopes or alluvial terraces):
 - On Tertiary Jurassic or Cretaceous rocks (clays, shale, marl, sandstone) **541** (Southern, Eastern hinterlands)
 - On coralline limestone **542** (Eastern Zanzibar, Pemba, Mafia)
 - On volcanic ash plains **544** (Northern)
- **Imperfectly to poorly drained soils:**
 - *Hardpan soils* (Gleysols, Solonetz, Planisols):
 - On Neogene sandy clays **601** (Eastern alluvial plains)
 - On old alluvium (Itogolo) **602** (Lake, Northern, Western)
 - On alluvium or (indurated) continental deposits or granite **604** (Central, Western, Lake)
 - On recent sediments **605** (Rukwa, Songwe in dry Southern Highlands)
 - On old stream deposits (terraces?) (sandy hardpan soils) **611** (Kilombero valley)

- *Fluvisol* (alluvial stratified soils:
 - Relatively younger, (coarse) sandy to loamy Fluvisols in floodplains **621** (Eastern, Southern coastal floodplains and deltas)
 - Relatively younger, loamy to clayey Fluvisols, usually in depressions:
 - On riverine floodplains **641** (Eastern coastal floodplains and Rufiji valley)
 - On clayey coastal sediments 643 (Western Zanzibar, Pemba, Eastern and Southern hinterland plains, CH physiographic units)
 - On clayey coastal sediments 644 (Eastern, Southern hinterland hills and dissected uplands, CD physiographic units)
 - In alluvial plains in subsidence basins **646** (Kilombero valley)
 - On alluvial complexes or floodplains, high rainfall A-climatic zones, **647a** (Kyela plain)
 - On lacustrine plains, low rainfall E-climatic zones **647b** (dry Southern Highlands)
 - in depressions and valleys on lavas and granite **648** (Tarime highlands)
 - In intramountain plains on gneiss 649 (Matengo highlands)
 - On sandstone 650 (Southern, Eastern sedimentary plateaux)
 - On granite **651** (Southern Highlands (Rukwa), Western, Lake)
 - On riverine floodplains **652** (Kagera, Mara)
 - In regularly flooded coastal deltas with marine influence (Acid sulphate soils, Thionic Fluvisols) 751 (Coastal delta of Rufiji river)
 - Relatively older, partly salty/sodic, usually clayey Fluvisols on terraces:
 - On older not regularly flooded alluvium **632** (Eastern alluvial plains)
 - On old alluvium **633** (Kilombero valley)
 - In lacustrine plains and floodplains **634** (dry Southern Highlands)
- *Gleysols*:
 - Moderately leached Gleysols or Gleyic Luvisols with relatively high base saturation (more than 50 % within 50 cm depth):
 - On recent, young alluvium **671** (Western swamps)
 - On recent alluvial or lacustrine sediments 672 (dry Southern highlands)
 - On sandstone, limestone, shale **674** (Southern, Eastern hinterland plains)
 - On limestone, marl and clay **675** (Southern, Eastern coastal plains)
 - On older alluvium over coastal plain limestone, marl and clay 676 (Western Zanzibar, Pemba, Eastern and Southern hinterland plains)
 - On alluvial terraces over sandstone, limestone and shale 677 (Eastern alluvial plains)
 - On continental deposits or Pleistocene cover over gneiss or granite 678 (Western, Central)
 - On old surfaces with indurated sediments over granite or gneiss **679** (Ruaha valley in dry Southern Highlands, Central, Northern)

- On gneiss and Basement complex with some admixture of volcanic ash 681 (Mbozi)
- On gneiss 682 (rocky terrain Mbeya/Mbozi hills and mountaineous areas)
- On phyllite 684 (Karagwe)
- On schist and granite 685 (Southern Highlands (Rukwa), Kagera)
- On sandstone and shale 686 (Southern Highlands, Western, Kagera)
- On basalt and argilleceous sandstone 687 (Kigoma)
- On coastal sand cover over gneiss or granite 688 (Southern, Eastern)
- On basic or intermediate gneiss or granite **691** (Lake, Western, Central, Southern Highlands)
- On sandstone and shale 692 (Southern, Eastern, Southern highlands (Ruvuma))
- Strongly leached, Gleysols or Gleyic Acrisols with low base saturation (less than 25 % within 50 cm depth):
 - On metamorphic rocks **701** (Western swamps)
 - On Pleistocene cover (continental deposits) over metamorphic rocks **702** (Western, Central)
 - On sandstone **704** (Kagera, Kigoma, Southern Highlands (Rukwa))
- *Vertisols* with ponded drainage:
 - On Neogene marl, sand and clay **721** (Southern, Eastern coastal plain)
 - On Paleogene limestone and marl **722** (Southern, Eastern hinterland plains)
 - On alluvial plains **723** (Eastern alluvial plains)
 - On alluvial plains **724** (Pangani river valley)
 - On Karroo sandstone and shale **725** (Gumbiro area, Ruvuma)
 - On stream deposits or on old alluvium, colluvium or lake sediments 726 (Western, Central)
 - On old lacustrine alluvium or colluvium **728** (Lake, Western Northern)
 - On recent lake and stream deposits **730** (Rukwa, Songwe in dry Southern highlands)
 - On volcanic ash **732** (Northern)
 - On metamorphic rocks or granite **735** (Southern Highlands, Western, Lake, Northern, Central)
 - On granite or gneiss **737** (Western swamps)
 - On metamorphic rocks or granite sediments (Mbuga) 738 (Lake (Sukumaland))
 - On old indurated sediments **740** (Western, Central)

- *Very salty and sodic soils* (Solonchak/Solonetz):
 - On regularly flooded delta plains **761** (Rujiji valley and coastal floodplains and deltas)
 - In subsidence basins with volcanic influence **762** (Pangani river valley)
 - On gneiss **763** (Central, Northern)
 - In flat subsidence basins **764** (Central, Western)
 - On lacustrine plains **766** (Ruaha in dry Southern Highlands, Central, Northern)
 - On alluvial or lacustrine plains **767** (dry Southern Highlands)
 - On old lake sediments **771** (Lake, Western, Northern)
 - In rift depressions **772** (dry Southern Highland, Central, Northern)
- *Peat soils*:
 - In subsidence basins **781** (Eastern alluvial plains)
 - On volcanic ash at high altitudes **782** (Northern)
 - In swamps on metamorphic rocks **783** (Western swamps)
 - In swamps on sandstone **784** (Kagera, Kigoma)
 - In swamps on schist **785** (Kagera)
 - In swamps on phyllite **786** (Karagwe)
 - In swamps on floodplains **787** (Kagera)

Maize/Bean		x	x		x			x		x	
Tobacco, s/cane			x	x	x			x			
Various 1 ¹		x	x	x	x	x	x	x		x	x
Cashew								x	x		
Various 2 ²									x		x
Various 3 ³									x		x
Millet, gr. leg., rice											

¹ Sorghum, pigeon pea, rice, sweet potato, maize, cotton, groundnut, sunflower, millet, sesame, dairy, pastoralism

² Rice, coconut, cassava, maize, cotton, trees, sugarcane, sisal

³ Sweet potato, cotton, sorghum, millet, sesame, pastoralism

2.3. Occurrence of the main constraints

Main soil constraints	Volc (1)	Volc (2)	Gneiss	Kagera Kigoma (1)	Kagera Kigoma (2)	Lac (1)	Lac (2)	Sand (1)	Sand (2)	VarR (1)	VarR (2)
Soil depth	(x)	(x)	x	x	(x)		(x)	x	(x)	x	(x)
Erosion, landslides	(x)	x	x	x	(x)			x	(x)		
Wind erosion		x									
Erosion, soil degradation		(x)	x			(x)	(x)				(x)
Fertility + leaching	(x)			(x)	x						
Fertility + acidity		(x)	x	x	x			?	?	x	x
Fertility + low organic matter			x			(x)	(x)	(x)	(x)	(x)	(x)
Compaction									(x)		
Capping/sealing	(x)		(x)	(x)	(x)	(x)	(x)				(x)
Workability		x	x				x		x		x
Salinity/sodicity		(x)	(x)			(x)	(x)		(x)	?	
Flooding/drainage				x	(x)	(x)	x	(x)		(x)	x
Drought		x	x	x	x	x	x	x	x	x	x
Radiation	x	x	x	x	x			(x)		(x)	
Temperature	x	x	x	x	x						
Humidity/excess rain					x						

Annex 3. Geology of Tanzania (according to CMU (1998))

3.1. List of geological formations

- Recent (R):
 - R1. Stream deposits (CMU-A1)
 - R2. Lake and stream deposits (CMU-F1, G1, G2)
- Sub-recent (SR):
 - SR1. Stream deposits (CMU-A2, B1)
 - SR2. Lake and stream deposits (CMU-H1, H2)
 - SR3v. Volcanics, basalts (CMU-E2, E2h, H2v, H4v)
- Pleistocene (P):
 - P1. Stream deposits (CMU-B2)
 - P2. Limestone, marl clay along coast (CMU-A3)
 - P3. Granite, (gneiss, Dodoma) with Pleistocene cover (CMU-G7, H4, H6)
 - P4v. Volcanics, basalts (CMU-E3, E3h)
- Karroo (Kar) with coastal sand cover: Shale, sandstone (CMU-B3d, F2d)
- Plio-Pleistocene (PP):
 - PP1. Coastal sand and clay (A4)
 - PP2. Coastal sand and clay (A4) over limestone, marl, clay (CMU-(A3), A4d)
 - PP3. Marl, sand, clay (CMU-H3)
 - PP4. Shale, sandstone (Karroo) partly covered by coastal sand (CMU-B3)
 - PP5. Gneiss (Mocambique) partly covered by coastal sand (CMU-B4)
 - PP6. Granite, gneiss with Plio-Pleistocene cover (CMU-G8)
 - PP7v. Volcanics, ash and tuffs (CMU-E1, E1h, C6v, D5v, D6v)
 - PP8v. Volcanics, basalts, phonolites (CMU-E4, E4h)
- Pliocene (Plio), volcanics, phonolites, ash (CMU-E5)
- Miocene (Mio), volcanics, phonolites, (CMU-E6)
- Jurassic-Paleogene (JP): sandstone, limestone, shale (CMU-A5, A5d)
- Bukoba (Buk):
 - Buk 1. Limestone, basalt (+ argillaceous sandstone) (Uha-Bukoba) (CMU-C1h, G3)
 - Buk 2. Sandstone (CMU-D2), sandstone (Uruwira) (CMU-C2), sandstone, shale (Uruwira) (CMU-C2h, G4h), sandstone, limestone (Uruwira) (CMU-D1)
- Karagwe-Ankolean (K/A):
 - K/A 1. Schist, granite (CMU-C3h, D3a, G5)
 - K/A 2. Phyllite, quartzite and conglomerate (CMU-D3, D3d)
- Ubendian (Uben), gneiss: CMU-C5, C5d, C5h, D6, D6d, G6, G6h
- Mocambique (Moc), gneiss: CMU-B5, B5d, B5h, C4, C4d, C4h, D4, granite, gneiss (CMU-D5, D5d)
- Dodoma (Dod), granite, gneiss: CMU-C6, C6h
- Granite (Pre-Cambrian, Basement Complex (BC): CMU-H5h

Annex 4. Available water holding capacity (data taken from de Pauw 1984)

4.1. AWC and S_{max} per agro-ecological zone of de Pauw (1984)

Agro-ecol. zone (de Pauw 1984)	AWC (mm)	Rating	S_{max}	Rating	Remarks on S_{max}
C1	30-80	vl-l	50-150	l	
C2	80-150	m	150-350	h	
E1	80-150	m	40-60	l	Surface sealing
E2	70-120	l-m	150-300	h	Surface sealing 70-100, chemical barrier 50-80
E3	80-150	m	200-350	h	
E4	70-120	l-m	200-400	h	chemical barrier 50-80
H1	100-200	h	> 400	vh	
H2	120	m	300-400	vh	
H3	70-120	l-m	150-200	m	surface capping 70-100
H4	80-150	m	300-350	vh	
N1			30-50	vl	sodicity
N2	70-150	m	200-400	h	
N3	50-100	vl-l	100-200	m	
N4	100-200	h	300-600	vh	
N5			0-50	vl	salinity, sodicity
P1	30-100	vl-l	50-150	l	sandy soils or loamy soils with surface capping
			150-300		other loamy soils
P2	150	h	200-250	h	
P3	30-100	vl-l	15-50	vl	
P4	50-100	l	100-200	m	chemical barrier 30-50
P5	70-150	m	150-225	m	
R1	80-150	m	150-350	h	some salinity, alkalinity reducing S_{max}
R2	50-100	vl-l	see P1		
S	50-80	l	100-150	l	
U	30-100	vl-l	see P1		
W1	70-120	l-m	200-400	h	chemical barrier 50-80
W2	50-100	vl-l	100-200	m	chemical barrier 50-80

Ratings

Rating AWC		Rating S_{max}		
30-65	vl	< 50	vl	
65-100	l	50-130	l	
100-135	m	130-210	m	
135-170	h	210-300	h	
>170	vh	> 300	vh	

4.2. AWC and S_{max} per soil unit (de Pauw) and soil type

Soil unit (de Pauw 1984)	Soil type no. (Vol.II)	Measured AWC (mm/1 m)	Estimated range in AWC (mm/1 m)	Rating	Smax	Rating	Remarks on S_{max}
1	231-234						
2	235 (231,232)	90 (80-100)	100-150	m-h	200-300	h	
3	251-252	125 (100-150)	100-150	m-h	30-50	vl	internal drainage, run-off
4	236-240	160	150	h	225	h	
5	271		120	m	300	h	
6	321-322	95	120	m	225	h	
7	331-344	45 (15-75)	50-80	vl-l	100-160	l-m	
8	421-425		100	l-m	150-300	m-h	surface capping 150
9	411-414	70	100	l-m	200	m	
10	401		100	l-m	200	m	
11	272-276	45	120	m	420	vh	
12	361-368	70 (50-90)	70-120	l-m	50-80-210-360	l-h	subsoil acidity barrier 50-80
13	381-382		100	l-m	250	h	
14	471-479	75	70-100	l	70-100-140-200	l-m	surface capping 70-100
15	391		70-100	l	50-80-140-200	l-m	subsoil acidity barrier 50-80
16	101-116		100	l-m	0-25	vl	
17	141-146		100	l-m	0-25	vl	
18	131-133		100	l-m	100	l	
19	(237)		120	m	240	h	
20	144		10-50	vl	10-50	vl	
21	301		10-30	vl	30-120	vl-l	salinity, brackish groundwater
22	311		10	vl	40	vl	
23	262-263	160 (120-200)	100-200	h	300-600	vh	
24	264-265	180	100-200	h	300-600	vh	
25	451-455	100 (95-105)	50-100	l	35-50-100-200	vl-m	subsoil acidity barrier 35-50
26	461-462	110	80-120	l-m	40-60	vl-l	surface sealing, run-off (vl)
27	501-509		30	vl	60-120	l	fluctuating groundwater
28	521-527		30-70	vl	60-140	l	
29	541-544	130	150	h	225	h	compact

							subsoil m
30	611		30	vl	45	vl	run-off addition
31	671-693	100	70-150	m	225	h	very compact subsoil l
32	701-704		70-150	m	30-225	vl-h	very compact subsoil l, chemical barrier vl
33	721-741		150	h	150	m	compact subsoil
34	601-605		30-100	vl-l	15-50	vl	hardpan
35	621		10-30	vl	40-90	vl-l	
36	201-210		80-120	l-m	240-360	h-vh	
37	641-652		150	h	300	h	compact subsoil
38	631-634		150	h	225	h	compact subsoil
39	761-772						alkali/sali ne soils
40	781-787						peat
41	751						acid sulphate soil

Annex 5. Rainfall data

5.1. Approximate annual rainfall per climatic zones A-E

Rainfall pattern	Monomodal		Transitional		Bimodal		
Drought risk (%)	Low (18-24)	Low (20-24)	Medium (24-30)	High (30-40)	Low (16-24)	Medium (24-30)	High very (30->
A (high)	>1000	>1100	>1300	>1500	>1200	>1350	>
B (medium)	800-1000	900-1100	1050-1300	1200-1500	1000-1200	1100-1350	1200-
C (low, variable)	600- 800	700- 900	850-1050	1000-1200	800-1000	900-1100	1000-
D (low, drought)	500- 600	550- 700	650- 850	800-1000	550/600-800	700- 900	800-
E (very low)	< 500	< 550	< 650	< 800	< 550/600	< 700	<

5.2. Drought risk and rainfall pattern

Zone	Subzone	Pattern	Annual rain	Long rains	Drought risk (%)	Rating	Short rains	Drought (%)
Ia	Tanga	bi	1000-1200	550-700	24	low	340-440	40
Ib	Dar	bi	1000-1200	550-700	24	low	< 340	> 40
II	Arusha-Moshi	bi	700-1200	350-750	30-36	high	140-340	40
IIIa	Dodoma-Tabora	mono	600-1000		24	low		
IIIb	Meatu-south Arusha	trans(-bi)	700-1000	450-550	24-30	medium	< 340	30-40
IIIc	Mara-Serengeti (north)	bi	700		20-40			
IIId	Morogoro-Ilonga	trans	1200-1800	700-1300	24-28	medium		
IIIe	Nachingwea	trans	1000-1200		24-28	medium		
IIIf	Mwanza-Shinyanga-Biharamulo	trans	800-1200	> 450	20-24	low	> 340	20
IIIg	West Kagera	bi	1000-1200	450-550	16-20	low	340-440	20
IV	Lake Victoria-Bukoba	bi	1100-1800	450-750	18	low	340-500	20-30
V	Lake Tanganyika	mono(-trans)	900-1100		22-24	low		
VIa	Chunya-Sumbawanga	mono	800-1200	> 700	18-24	low		
VIb	Iringa-Mbeya	mono	1200-2200	> 700	22	low		
VIc	Songea-Njombe	mono	1200-1400	> 1200	18-22	low		
VId	Tunduru-Masasi	mono	1000-1200	> 900	18-24	low		
VIIa	Kilwa	trans(-mono)	900-1000	< 1000	24	low		
VIIb	Mtwara	mono	1000	< 1000	24	low		

Zone IIIb has in general highest drought risk

Zone IV has in general lowest drought risk.

Rating: < 25 % risk, low (usually 16-24 %); 24-30 % medium, 30-40 % high

[Source: B.S. Nyenzi et al. 1997. A study on long range weather forecasting in Tanzania. research report No. 1/97. Directorate of Meteorology, Dar es Salaam.]

5.3. Division into major climatic zones

Zone	Drought risk	High-medium rainfall	Low rainfall	Very low rainfall
Ia	low/high, bi	B, short rains uncertain		
Ib	low/very high, bi	B, short rains very uncertain		
II	high, bi	A, > 1200 mm, B, 800/1000-1200, C, 600/800-800/1000 mm annually	D, 550-600/800 mm annually	E, any other
	East side of large mountains, bi	A, > 1250 mm annually, B, 1000-1250 mm	C, 800-1000 mm	D, 650(600/700)-800 mm; E, any others
	Still influenced by mountains, southern or eastern sides, bi	A, > 1375, B, 1100-1375	C, 900-1100	D, 700/750-900; E any others
	Others, bi	A, > 1500 mm annually, B 1200-1500 mm annually	C, 1000-1200 mm	D, 800-1000 mm; E, any other
	Others, trans	A, > 1400 mm annually, B, 1100-1400 mm	C, 900-1100 mm	D, 700/800-900 mm, E, any other
IIIa	low, mono	B, > 750/800 mm	C, any other	
IIIb	medium-high, trans/bi	C, > 800 (better > 900) mm annually; B, > 1100/1200 mm	D, > 650/700 mm annually	E, any other
IIIc	low/high, bi	B, west Mara, > 800 mm annually	C, 600-800 mm annually	D, 500-600 mm annually; E, any other
	West Mara, bi	B, > 1000 mm annually	C, any other	
	East Mara, bi	C, > 1000 mm annually	D, 800-1000 mm annually	E, any other
	Serengeti-north, bi	C, > 1200 mm annually	D, 1000-1200 mm annually	E, < 1000 mm annually
IIId	medium, trans	A, highland areas, > 1250 mm annually	B, > 900/1000 mm annually	C, any other
IIIe	medium, trans	B, > 1000 mm annually	C, 800-1000 mm	D, any other
IIIf	low, trans	A, > 1000 mm annually	B, 800-1000 mm annually	C, any other
IIIg	low, bi	A, > 1200 mm annually	B, 1000-1200 mm	C, 800-1000 mm; D, any other
IV	low, bi	A, > 1200 mm, B, 1000-1200 mm	C, 800-1000 mm	D, any other
V	low, mono (north of Lake T., trans)	A, > 1000 mm, B, 800-1000 mm	C, any others	
VIa	low, mono	A, > 1000 mm, B,	C, 600-800 mm	D, 500-600 mm, E,

		800-1000 mm		any other
VIb	low, mono	A, > 1000 mm, B, 800-1000 mm	C, 600-800 mm	D, any other
VIc	low, mono	A, > 1000 mm, B, 800-1000 mm	C, 600-800 mm	D, any other
VIId	low, mono	A, > 1000 mm, B, 800-1000 mm	C, 600-800 mm	D, any other
VIIa	low, trans (transitional towards mono)	B, > 800/900	C, any other	
VIIb	low, mono	B, > 800 mm	C, any other	

5.4. Annual rainfall related to drought risk and rainfall pattern

	Low	Medium	High
Mono-A	> 1000	> 1200	> 1500
Mono-B	800-1000	1000-1200	1200-1500
Mono-C	600-800	800-1000	1000-1200
Mono-D	500-600	600-800	800-1000
Mono-E	Any other	Any other	Any other
Trans-A	(> 1100)	(> 1275)	> 1500
Trans-B	(900-1100)	(1050-1275)	1200-1500
Trans-C	(700-900)	(850-1050)	1000-1200
Trans-D	(550-700)	(650-850)	800-1000
Trans-E	Any other	Any other	Any other
Bi-A	> 1200	> 1350	> 1500
Bi-B	1000-1200	1100-1350	1200-1500
Bi-C	800-1000	900-1100	1000-1200
Bi-D	600-800	700-900	800-1000
Bi-E	Any other	Any other	Any other

5.5. Temperature regimes (de Pauw 1984)

Regime	Mean annual maximum temperature	Mean annual minimum temperature
1 (warm)	29-31	19-23
2 (intermediate)	27-30	15-18
3 (cool)	22-25	10-15
(4, altitudes above 2300 m)	16-19	5-10 (possibly frost in dry season)

Annex 6. IPNM options for three study areas

6.1. OPTIONS FOR INTEGRATED SOIL FERTILITY MANAGEMENT, FARMING SYSTEM ZONE 7, BUKOBA HIGH RAINFALL ZONE, KAGERA, LAKE ZONE

The options for FSZ 7 are divided into manure, compost, crop residue, mulch, green manure, Rweya (soil type), (mineral) fertilizer and lastly ash and lime application options.

MANURE OPTIONS

Manure storage

Option Ma 1. For good and medium soil fertility managers: improve storage and increase total quantity of manure by bedding, covering, roofing; allow the manure to decompose properly before application.

Option Ma 2. Use manure from dairy cattle.

Option Ma 3. For medium and poor soil fertility managers: use manure from ruminants

Manure application

Option Ma 4. Apply per soil fertility manager category of farmer:

- good: at least 3 debes, medium: 2-3 debes and poor: 2 debes manure in each planting hole of banana or coffee at the Kibanja as deep as possible.

Option Ma 5. Apply per soil fertility manager category of farmer:

- good: (2 tons/ha), medium: (0.7 tons/ha) and poor: as much as possible manure in furrows between the banana at the Kibanja every year.

Option Ma 6. Apply per soil fertility manager category of farmer:

- good: (1 ton/ha), medium: (300 kg/ha) and poor: as much as possible manure by spreading and incorporating between the coffee trees at the Kibanja every year.

Option Ma 7. For good and medium soil fertility managers: apply (1.75 tons/ha) manure on maize, fodder grass or vegetables on Kikamba if the maize yield is expected to be more than (1500 kg/ha).

COMPOST OPTIONS

Option Co 1. Make compost of all (organic) household refuse with proper shelter and by adding small quantities of bonemeal, ashes, green manure. Apply especially on vegetables and beans.

RESIDUE OPTIONS

Option Re 1. Hull coffee on the farm and spread husks evenly round the coffee trees at the Kibanja.

Option Re 2. Use remainder of brewing bananas to be spread around bananas at the Kibanja.

Option Re 3. Mix (low quality) residues as bedding in the kraal or mix in the compost pit.

Option Re 4. Burn residues with (noxious) weeds and use ashes in the compost pit and spread around banana at the Kibanja.

MULCH OPTIONS

Option Mu 1. At sites without direct protection against heavy rains, apply thick layer of mulch, using Rweya grasses or weeds.

Option Mu 2. Use mulch for weed control and moisture conservation on newly established coffee and banana fields.

GREEN MANURE OPTIONS

Option Gm 1. Interplant (Mucuna) or (Canavalia) four weeks after maize on Kikamba. Incorporate the green manure before planting the next crop or leave as mulch.

Option Gm 2. Plant (Crotalaria) as pure stand on Kikamba and incorporate before planting next maize crop.

RWEYA OPTIONS

Option Rw 1. For good soil fertility managers: use some manure on omusiri fields.

Option Rw 2. Apply in two splits per year a quantity of (120 to 150 kg/ha) of (urea) on tea clones K35 and 7/3 and up to (650 kg/ha) on other tea clones.

Option Rw 3. Use cattle licks.

MINERAL FERTILISER OPTIONS

Option Fe 1. For good and medium soil fertility managers: apply (30 g) of (CAN) to young coffee trees (of up to 5 years old) and (60 g) of (CAN) to older coffee trees, to be applied twice a year at the beginning of the short and the long rains.

Option Fe 2. For good soil fertility managers: apply (x kg/ha) of Multi-K to banana in as many splits as possible, avoiding heavy rainy periods.

Option Fe 3. For good soil fertility managers: use (copper) sprays on coffee.

Option Fe 4. For good and medium soil fertility managers: apply (30-40 kg/ha) of (CAN), (50 kg/ha) of (Multi-K) and (2 kg/ha Mg as MgSO₄) to maize on Kikamba in two splits after weeding.

ASH AND LIME APPLICATION OPTIONS

Option A/l 1. On poor growing spots or parts of the Kibanja or Kikamba, per category of soil fertility manager:

- Good: Together with a proper mulch, incorporate small quantities of ash or (dolomitic lime) and repeat until growth of crops become normal. If lime is used and no (Mg-deficiency) occurs in banana, combine with (potassium) fertilizer, to be applied in small quantities after the lime application, until growth of the crop improves. The effect of these practices may take several years to

show and should therefore be applied every three months, preferably during the drier periods of the year.

- Medium and poor: Use ashes in small quantities and repeat until growth of crops becomes normal.
- Make ridges to increase rooting depth and grow cassava, maize and sweet potato on them.

6.2. OPTIONS FOR INTEGRATED SOIL FERTILITY MANAGEMENT, FARMING SYSTEMS ZONES 1 AND 2, LUSENI-ITOGOLO DOMINATED ZONES, SUKUMALAND, LAKE ZONE

The options for FSZ 1 and 2 are divided into Luseni (soil type), Kikungu/Nduha (soil type), vegetables, rice, manure/compost, crop residue, ridge, intercropping and Mbuga (soil type) options.

LUSENI OPTIONS

Option Lu 1a. Apply once in three or four years before planting maize, per category of soil fertility manager:

- good: (5 tons/ha), medium: (2.5 tons/ha) or preferably more and poor: as much as possible of manure of good quality.

Option Lu 1b. Apply once in three or four years before planting maize, per category of soil fertility manager:

- good: (200 kg/ha), medium: (50-100 kg/ha) and poor: if possible at least some quantity of (Minjingu rockphosphate). Mix the (rockphosphate) with the dry manure just before application and mix as deep as possible in the topsoil during land preparation. If no (rockphosphate) is available:

Option Lu 1c. Apply once in three or four years before planting maize, per category of soil fertility manager:

- good: (1 bag/ha) of (TSP) or preferably (SSP), medium: (0.5 bag/ha) of (TSP) or preferably (SSP).

Option Lu 1d. Apply once in three or four years before planting maize, per category of soil fertility manager:

- good: preferably (1 bag/ha) of (K₂SO₄), medium and poor: if possible some (KCl or K₂SO₄) in the furrows during ridge making.

Option Lu 2. Use good seed and weed timely.

Option Lu 3. Apply per category of soil fertility managers:

- good: (1 or 1.5 bags/ha), medium and poor: (1 bag/ha) of (urea), preferably in two to three splits, after weeding the maize, when rains are good. Try more, up to (3 bags/ha) of (urea) the next year.

Option Lu 4. Intercrop maize with a legume (cowpea, bambara nuts, green gram, groundnut, pigeon pea), which can grow part of the dry season.

Option Lu 5. Either grow cotton, cassava or sweet potato after maize. Intercrop cassava with a legume or (Tephrosia) which can grow during part of the dry season. Protect the legumes from grazing during the dry season.

Option Lu 6. If cotton is planted in the year after maize and is expected to yield more than (750 kg/ha) of seed cotton, apply (1 bag/ha) of urea after weeding the cotton, when the rains are good.

Option Lu 7. Plant multi-purpose trees and shrubs along field boundaries and around permanent kraal sites.

Option Lu 8. After years with good production increase the quantities of fertilizers to the maximum, as indicated.

KIKUNGU/NDUHA OPTIONS

Option K/N 1a. Apply once in three to four years before planting maize, per category of soil fertility managers:

- good: (5 tons/ha), medium: (2.5 tons/ha) and preferably more and poor: as much as possible manure of good quality.

Option K/N 1b. Apply, per category of soil fertility managers:

- good and medium: (200 kg/ha) and poor: if possible at least some quantity of Minjingu rockphosphate in the furrows during ridge making before planting maize. Mix the rock phosphate with the dry manure just before application and mix as deep as possible in the topsoil during land preparation. If rockphosphate is not available:

Option K/N 1c. Apply, per category of soil fertility managers:

- good: (0.5-1 tons/ha) of ((dolomitic) lime) once every four years or increase the manure to (7 tons/ha) and medium: (1 bag/ha) of (TSP) or increase the quantity of manure.

Option K/N 2. In Bukangiliya village, for good soil fertility managers, apply (1 bag/ha) of K₂SO₄ in the furrow before planting maize.

Option K/N 3. Use good seed and weed timely.

Option K/N 4. Apply (1 to 1.5 bags/ha) urea after weeding the maize, when rains are good. Try out up to (2 bags/ha), if the rains are good. In higher rainfall areas like Mara district not more than (1 bag/ha) of urea/ha should be given. Make sure that (urea) application is combined with manure application.

Option K/N 5. Intercrop maize with a legume (cowpea, bambara nuts, green gram, groundnut, pigeon pea), which can grow during part of the dry season. Protect the legume from grazing during the dry season.

Option K/N 6. Either grow cotton, cassava or sweet potato after maize. Intercrop cassava with a legume or (Tephrosia) which can grow during part of the dry season.

Option K/N 7. Apply (1 bag/ha) of (TSP) during ridge making before planting cotton in the year following the maize. Try more, up to (3 bags/ha) the next year.

Option K/N 8. Only when cotton is expected to yield more than (750 kg seed cotton/ha) apply (1 to 1.5 bags/ha) of urea after weeding.

Option K/N 9. Plant multi-purpose trees and shrubs along field boundaries and permanent kraal sites.

Option K/N 10. On exhausted Kikungu or Nduha fields after a long period of continuous cultivation, especially in the higher rainfall areas like in Mara district, apply once in four years (0.5 tons/ha) of lime and mix as deep as possible in the topsoil during land preparation. Follow with option K/N 1.

Option K/N 11. After years of good production increase the quantities of fertilizers to the maximum, as indicated.

VEGETABLES OPTIONS

Option Ve 1. Apply, per category of soil fertility managers:
 - good: (5 tons/ha) of manure of good quality and (1 bag/ha) of K₂SO₄ or NPK (20:10:10) and medium and poor: any quantity of manure or compost of good quality

Option Ve 2. Grow maize or cotton after the vegetables and apply (1 bag/ha) urea after weeding the maize or cotton.

RICE OPTIONS

Option Rc 1. For good soil fertility managers, when rice yields were disappointing during the last years, apply (1 bag/ha) of NPK (20:10:10) during land preparation and planting of the next crop of rice.

Option Rc 2. In Bukangiliya village, for good soil fertility managers, apply (1 bag/ha) of (K₂SO₄ or KCl) during land preparation.

Option Rc 3. When the varieties rangi mbili, lungunguma or super are used, apply per category of soil fertility managers:
 - good and medium: (1 bag/ha) of urea (try out up to (4 bags/ha) of urea the next year) and poor: any quantity of (urea) directly after or during weeding.

Option Rc 4. Keep a water layer in the fields and weed timely.

Option Rc 5. Plant leguminous trees in neighbourhood of rice fields and apply the leaves to the rice fields in the first month after transplanting or the first eight weeks after seeding. In this way the quantity of urea can be reduced.

Option Rc 6. Grow sunflower, (green) maize, sorghum or chickpeas if rains stay out.

Option Rc 7. After years with good production increase the quantities of fertilizers to the maximum, as indicated.

Option Rc 8. For good and medium soil fertility managers, apply, if rice yields seems to be decreasing, any quantity of manure in seasons when no rice is grown and incorporate the rice straw.

MANURE/COMPOST OPTIONS

Manure and compost production

Option M/C 1. Add straw to the kraal, remove manure weekly and store manure under cover or in covered pits.

Option M/C 2. Shift kraal site from time to time.

Option M/C 3. Build kraal site near field to be fertilizer with manure.

Option M/C 4. Grow green manure crops as intercrop between maize or cassava or as relay crop after maize and feed the residues to the

cattle or add to the compost pit. Let cattle browse from leguminous trees and shrubs.

Manure or compost application

Option M/C 5. Add, per category of soil fertility managers:

- good and medium: (20-50 kg) Minjingu rockphosphate per (ton) of manure directly before application of the manure or compost to the maize and vegetable fields and poor: if possible at least some quantity of Minjingu rock phosphate to be mixed with the manure or compost to be applied to the field.

Option M/C 6. For poor soil fertility managers, instead of manure, use compost of good quality on the maize and vegetables fields.

RESIDUE OPTIONS

Option Re 1. If the topsoil of sandy soils like Luseni is very light coloured, do not incorporate more than (2 tons/ha) of straw. Use the remainder of the straw as bedding in the kraal.

Option Re 2. Residue remaining after grazing could be used as bedding in the kraal.

Option Re 3. Burning of crop residues should only be done in case of pest control.

Option Re 4. Incorporate rice husks as much as possible.

Option Re 5. If crop residues are being grazed by cattle, that are not owned by the farmer, barter for manure, transport or ploughing the next season.

RIDGE OPTIONS

Option Rd 1. On more sloping land ridges of sufficient height along the contour prevents run-off. Incorporate weeds as much as possible, well in advance of planting the next crop.

Option Rd 2. In drier areas or during drier rainy seasons on upper slope positions, try out, per category of soil fertility managers:
- good and medium: tied ridges by plough or hand hoe and poor: tied ridges by hand hoe if possible.

Option Rd 3. Make contourbunds or large ridges planted with grass or leguminous shrubs along the contour on the steepest slopes.

Option Rd 4. When making the ridges, per category of soil fertility managers:

- good: spread residues and manure and medium: incorporate the manure into the ridge.

INTERCROPPING OPTIONS

Option In 1. Intercropping with legumes, per category of soil fertility managers:

- good: less relevant, medium: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields and poor: important to intercrop with legumes as much as possible, especially on fertilized vegetable fields.

Option In 2. Relay cropping of legumes as much as possible by planting the legume during the rainy season in between another crop and to leave the legume to continue to cover the field after the harvest of the main crop.

MBUGA OPTIONS

Option Mb 1. Apply some manure if possible to maize or other cash crop.

6.3. OPTIONS FOR INTEGRATED SOIL FERTILITY MANAGEMENT, SMALL SCALE MECHANIZED MIXED FARMING SYSTEM ZONE Mc2, ARUMERU/HAI, NORTHERN ZONE

The options for FSZ Mc2 are divided into manure, compost, soil conservation, fodder, relay cropping, cropping, cattle, ruminants, mineral fertilizer and inoculant options.

MANURE OPTIONS

Option Ma 1. Apply, per category of soil fertility managers:

- good: (3-4 tons/ha), medium: (1-3 tons/ha) and poor: (0.5-1 tons/ha)

good quality manure on maize/bean. Medium and poor managers could also add ashes as much as possible.

Option M/C 2. Use a good quantity of good quality manure or compost to the vegetables as possible.

Option Ma 3. For good and medium soil fertility managers: use fresh manure on banana.

Option Ma 4. Improve storage conditions of manure, e.g. by applying straw to the kraal and observe better growth of crops after proper decomposition of the manure to be applied.

Option Ma 5. Use manure especially at (high-response) crops (like cassava, sweet potato).

Option Ma 6. For medium soil fertility managers: enrich the manure just before application with a small quantity of (rockphosphate) in the case of Hai and (TSP) in the case of Arumeru.

COMPOST OPTIONS

Option Co 1. For medium and poor soil fertility managers: make as much compost as possible and use proper methods [to be named].

SOIL CONSERVATION OPTIONS

Option Cs 1. Plant (multi-purpose trees) at sites with (dominant) wind during the dry periods, and also as hedges, woodlots, life fences as well as around the homestead.

Option Cs 2. On lowland sites special drought-resistant and goat-resistant and sometimes salt-resistant trees [to be named] should be selected. Make small depressions on lowland sites to be planted with perennial grasses, shrubs or trees. Possibly use some manure.

Option Cs 3. Use crop residues as mulch. Only burn residues for pest control (e.g. stalkborers).

Option Cs 4. Make ridges or even tied-ridges on sloping fields (Hai only).

Option Cs 5. For good and medium soil fertility managers: use better implements for tillage and harrowing instead of (disc ploughs), e.g. (chisel-, paraplooughs). Only use disc ploughs or disc harrows when no alternatives are available or when alternatives are not properly doing the necessary action required. Plough parallel to the contour on sloping land (especially Arumeru).

Option Cs 6. Establish (storm drains) and (water basins) to (evacuate) running water during heavy rain periods in sloping land (mainly part of Hai).

Option Cs 7. Establish contour bunds on sloping land, and protect them with (perennial) grasses. Plant such grasses also around fields, unless they might become weeds in the fields. Such grasses could also be planted in (gullies) (on sloping land, especially in Arumeru).

Option Cs 8. For good soil fertility managers: (dry plough or harrow) to shallow depth after grazing to conserve moisture.

Option Cs 9. Fill gullies with stones or small dams to reduce speed of running water and to create water basins (maybe applicable in part of Hai).

Option Cs 10. For medium and poor soil fertility managers: prevent grazing by livestock from other farmers by planting (live fences) of drought tolerant, thorny, goat-resistant shrubs.

FODDER OPTIONS

Option Fo 1. Plant (useful species) on field boundaries and on contour bunds.

RELAY CROPPING OPTIONS

Option Rl 1. Plant (green manure species, e.g. semi-perennial pigeon pea, lablab, jackbean, mucuna) after establishment of the main crop, in order to create cover or mulch during part of the dry season.

CROPPING OPTIONS

Option Cr 1. Diversify the types of crops by trying sunflower, and others [to be named]. Try out (early-maturing varieties) of the main crops.

CATTLE OPTIONS

Option Ca 1. For good soil fertility managers: improve cattle management (to be specified).

RUMINANT OPTIONS

Option Ru 1. For medium and poor soil fertility managers: improve small ruminant management (to be specified).

MINERAL FERTILISER OPTIONS

Option Fe 1. Topdress during the long rainy season on midland sites maize((long duration maize)[to be named]/beans, depending on the actual rainfall after timely sowing and weeding and when using good quality seed, with, per category of soil fertility managers:
- good: (1 to 4 bags/ha), medium: (1-2 bags/ha) of (urea), to be applied one-third at (emergence) and two-third when the maize is at knee height. Try out (one bag/ha) first and observe the increase in maize and/or bean yields. If increase is satisfactory and weather conditions are good, try out more (urea).

Option Fe 2. For good and medium soil fertility managers: apply (one bag/ha) urea on vegetables like tomato, (cabbage), and (mustard) and (nightshade). For irrigated vegetables (one bag of NPK (20:10:10) could be tried instead of urea.

Option Fe 3. When mulch is decomposed to some extent and coffee yields are more than (500 kg/ha), use (ammonium sulphate) of, per category of soil fertility managers:

- good: up to (seven bags/ha) or instead use (3-4 bags/ha) of (urea) and medium: up to (four bags/ha) or instead use (1-2 bags/ha) of (urea) on coffee in three to six splits every year. Increase these amounts somewhat when mulching heavily.

Option Fe 4. For good and medium soil fertility managers: use some (urea) and (KCl) on Irish potato.

Option Fe 5. For good and medium soil fertility managers: try out (1 bag/ha) of (urea) on wheat as topdressing, if weather conditions are good. If successful, try out up to (2 bags/ha) of urea. If (manganese deficiency) is occurring, use (2-3 bags/ha) of (ammonium sulphate) instead.

INOCULANT OPTIONS

Option Io 1. For good and medium soil fertility managers: use (inoculants) as (sticker) on bean seed.

Annex 7. Data on carrying capacity and percentage cultivation (data derived from de Pauw (1984) and NCU (1996))

Agro-ecol. zone de Pauw (1984)	Av. LCC	Rating	% Cult. (1982)	% Cult. (est. 2000)*	Rating
C1	18	l	25	43	m
C2	17	l	70	100	vh
C3	16	l	60	100	vh
C4	15	l	55	94	h
C5	22	m	20	34	l
C6	33	h	100	100	vh
C7	33	h	100	100	vh
E1	2	vl	<1	1	vl
E2	5	vl	46	78	h
E3	17	l	30	51	m
E4	22	m	29	49	m
E5	17	l	40	68	h
E6	26	m	100	100	vh
E7	30	h	22	37	m
E8	5	vl	< 1	1	vl
E9	20	m	52	88	h
E10	40	vh	50	85	h
E11	18	l	27	46	m
E12	15	l	67	100	vh
E13	26	m	78	100	vh
E14	28	h	50	85	h
E15	30	h	69	100	vh
H1	12	l	52	88	h
H2	25	m	86	100	vh
H3	30	h	59	100	vh
H4	33	h	100	100	vh
H5	33	h	79	100	vh
H6	33	h	100	100	vh
H7	23	m	33	56	m
N1	10	l	38	65	m
N2	34	h	< 1	1	vl
N3	5	vl	10	17	l
N4	44	vh	46	78	h
N5	15	l	58	99	vh
N6	7	l	13	22	l
N7	16	l	0	0	vl
N8	17	l	9	15	l
N9	24	m	0	0	vl
N10	33	h	100	100	vh
P1	9	vl	24	41	m
P2	4	vl	18	31	l
P3	10	l	20	34	l
P4	14	l	60	100	vh
P5	16	l	17	29	l
P6	16	l	3	5	vl
P7	7	vl	83	100	vh
P8	11	l	84	100	vh
P9	6	vl	25	43	m
P10	3	vl	2	3	vl
P11	4	vl	52	88	h
P12	12	l	56	95	h

P13	20	m	< 1	1	vl
R1	22	m	12	20	l
R2	20	m	12	20	l
R3	11	l	< 1	1	vl
R4	3	vl	< 1	1	vl
S1	15	l	3	5	vl
S2	15	l	6	10	l
U	20	m	53	90	h
W1	22	m	52	88	h
W2	27	m	46	78	h
W3	22	m	63	100	vh
W4	22	m	55	94	h

Ratings

Rating LCC	2-9	vl	Rating % Cult. (2000)	< 5	vl
	10-18	l		5-35	l
	19-27	m		35-65	m
	28-36	h		65-95	h
	37-45	vh		> 95	vh

- Based on 1982 data plus 3 % per year (1982-2000, assumed total increase of 70 %)

Annex 8. List of 186 different soil types and their occurrence in soil groups and agro-ecological zones.

Soil number	Soil group(s)	Broad AEZ group	Agro-ecological zones
102	4a,b	Vo-II	Vo-3,5b,6
103	1b	Vo-I	
104	6	Gn	
105	1a	Vo-I	
105	4b	Vo-II	
106	25b	Me-I	Me-2a?
106	29a,b	Ka-II	Ka-4a
106	7a,c	Ka-I	Ka-4c
107	15a(b?)	Sa-II	Sa-2a
108	25e	Me-I	
108	29a	Ka-II	
108	7c	Ka-I	Ka-1,2,4a
109	11	La-II	La-2
110	14	Sa-I	Sa-1
111	3	Gn	Gn-5a
111	18	Lw-II	
111	26	Me-II	
111	1a,b	Vo-I	
111	21a,b	Me-I	Se-3b
111	25a,c,d,e	Me-I	Me-2b,4a,5a,6b
111	4a	Vo-II	
111	5a,b	Gn	Gn-1b,2,3,5b,6a,7
113	20	Ka-II	
113	7b	Ka-I	
114	7a	Ka-I	
115	17	Lw-I	Lw-2a,3a
115	25a	Me-I	Me-3
116	17	Lw-I	Lw-3a
116	7c	Ka-I	Ka-1,4a?
131	21a,b	Me-I	
131	25e	Me-I	Me-6b
131	5b	Gn	Gn-6b
132	4a	Vo-II	
133	1a,b	Vo-I	Vo-1a,1b
142	4a,b	Vo-II	Vo-3,5b,6
144	19	Co-I	Co-1a
146	5a	Gn	Gn-1b
201	28	Me-III	Me-5b
203	10	Ka-I	Ka-4b
203	10	Lw-II	Lw-2b
204	11	La-II	La-4a
205	12	Me-II	Me-4c
206	9	Me-I	Me-2c
208	5a	Gn	
209	6	Gn	
210	25a,c,d	Me-I	Me-4a,6a
210	29b	Ka-II	
231	4a,b	Vo-II	Vo-3,5a,5b,6,(Gn-6b)
232	4b	Vo-II	Vo-4c,5a,6
236	15a,b	Sa-II	Sa-2b

237	5a,b	Gn	Gn-5c
238	8	La-I	La-3
239	22a	Se	Se-2
251	4b	Vo-II	Vo-4c,5a
261a	4b	Vo-II	Vo-5a,6
261b	1a,b	Vo-I	Vo-1a,1b
262	4a,b	Vo-II	Vo-1c,5b,6
264	2	Vo-I	Vo-2
265	1a,b	Vo-I	Vo-1a,1b,4a
271	4a,b	Vo-II	Vo-1c,3,6
272	1a,b	Vo-I	
272	5a,b	Gn	Gn-1b,2,3,4,5b,6a
273	6	Gn	Vo-4b
274	25e	Me-I	
275	2	Vo-I	
275	3	Gn	Gn-1a
275	1a,b	Vo-I	Vo-1a,1b
276	7a,b,c	Ka-I	Ka-1,3a
301	19	Co-I	
311	4b	Vo-II	
321	4a,b	Vo-II	Vo-1c,3,5b
322	5?		
331	27	Co-II	Co-1b,2b,3b
332	23	Me-III	Me-5d
332	5a	Gn	
333	19	Co-I	
334	26	Me-II	Me-5c,7
335a	26	Me-II	Me-4b
335a	25c,d,e	Me-I	Me-1,2b,4a,6a,6b
335b	11	La-II	La-4a
335b	21a,b	Me-I	Se-3b
335b	5a,b	Gn	Gn-7
336	18	Lw-II	Lw-2c,3b
337	20	Ka-II	Lw-1a
338	5a,b	Gn	Gn-3,4
339	25a	Me-I	Me-3,4a
340	14	Sa-I	Sa-1,2a,3a,4,5
341	29a,b	Ka-II	Ka-2,4c
343	11	La-II	La-2,4a
343	21a,b	Me-I	Se-3b
361	6	Gn	Vo-4b
362	26	Me-II	Me-4b,5c,7
362	5a,b	Gn	Gn-1b,2,3,5c,6b
362	4a	Vo-II	
364	3	Gn	Gn-1a
364	1a,b	Vo-I	Vo-1a,1b
364	25c	Me-I	Me-1,2a
364	29b	Ka-II	Ka-4c
365	7c	Ka-I	Ka-1,4a
366	17	Lw-I	Lw-2a,3a
367	7a,b,c	Ka-I	Ka-1,3a
368	29a	Ka-II	Ka-2,4c
381	25e	Me-I	Me-2b,4a,6b
382	18	Lw-I	Lw-3b
391	29a	Ka-II	Ka-2,4c

401	19	Co-I	Co-1a
411	6	Gn	Vo-4b
412	26	Me-II	Me-4b, 5c, 7
412	5a, b	Gn	Gn-1b, 2, 5c, 6b
414	11	La-II	La-2
421	21a, b	Me-I	
421	25a, d, e	Me-I	Me-1, 2b, 4a, 5a, 6a, 6b
421	29b	Ka-II	Ka-4c
421	5a, b	Gn	Gn-2, 6b, 7
422	25a	Me-I	Me-3
423	18	Lw-II	Lw-2c, 3b
424	29a	Ka-II	Ka-2, 3b, 4c
425	11	La-II	La-2, 4a
425	21a	Me-I	Se-3b?
451	27	Co-II	Co-2b
452	26	Me-II	Me-4b, 5c
454	18	Lw-II	Lw-3b
455	21b	Me-I	Se-3b
461	16	Gn	
461	26	Me-II	Me-7
461	25e	Me-I	Me-6b
461	5a, b	Gn	Gn-1b, 3, 4, 5c, 6b, 7
462	8	La-I	La-3
471	24	Co-II	Co-3a
473	3	Gn	
473	26	Me-II	Me-4b, 5c
473	1a	Vo-I	Vo-1a, 1b
473	25a, c, e	Me-I	Me-1, 2a, 4a, 6b
473	29b	Ka-II	Ka-4c
473	5a	Gn	Gn-3, 5a, 5b, 6a
474	20	Ka-II	Lw-1a
475	25a, b	Me-I	Me-2a?, 3
476	26	Me-II	Me-4b, 5c, 7
477	25d	Me-I	Me-4a, 6a
477	29a, b	Ka-II	Ka-3b, 4c
478	2	Vo-I	Vo-2
479	7a, c	Ka-I	Ka-1
501	26	Me-II	
501	1a	Vo-I	
501	21a, b	Me-I	
501	25a, c, d, e	Me-I	Me-4a, 6a
501	4a	Vo-II	
501	5a, b	Gn	
502	18	Lw-II	Lw-2c
503	26	Me-II	Me-4b, 5c
504	25a	Me-I	Me-3
505	20	Ka-II	
506	25c	Me-I	Me-1
506	29a	Ka-II	Ka-4c
507	21b	Me-I	Se-3b
508	22a	Se	
509	11	La-II	La-2, 4a
509	21a	Me-I	
521	23	Me-III	Me-5d
522	19	Co-I	Co-1a, 2a

523	27	Co-II	
524	24	Co-II	
527	14	Sa-I	Sa-3a, 4
541	15a, b	Sa-II	Sa-2b, 3b
542	19	Co-I	
543	4a	Vo-II	
544	4b	Vo-II	
601	23	Me-III	Me-5d
602	8	La-I	La-1, 3
602	18	Lw-II	Lw-2c
604	21a	Me-I	
604	22a, b	Se	Se-2
604	25e	Me-I	
605	11	La-II	La-2, 4a
605	21a	Me-I	
611	12	Me-II	Me-4c
621	28	Me-III	Me-5b
632	23	Me-III	Me-5d
633	12	Me-II	Me-4c
634	11	La-II	La-2, 4a
641	28	Me-III	Me-5b
643	27	Co-II	
644	24	Co-II	
645	24?		
646	12?		
647a	9	Me-I	Me-2c
647b	11	La-II	La-4a
648	6	Gn	
648	12	Me-II	Me-4c
649	5a	Gn	
650	14	Sa-I	
651	25a, c, d	Me-I	Me-4a, 6a
651	29b	Ka-II	
652	10	Ka-I	Ka-4b
652	10	Lw-II	Lw-2b
671	13	Lw-II	Lw-1b
672	11	La-II	
674	15a, b	Sa-II	Sa-2b, 3b
675	19	Co-I	Co-2a
676	27	Co-II	
677	23	Me-III	
678	18	Lw-II	
679	21b	Me-I	Se-3b
680	??		
681	2	Vo-I	
682	3	Gn	
684	7c	Ka-I	
685	7c	Ka-I	
685	17	Lw-I	
685	25a, d	Me-I	
686	7c	Ka-I	
686	29a, b	Ka-II	
687	20	Ka-II	
687	7b, c	Ka-I	
688	26	Me-II	

691	18	Lw-II	Lw-3b
691	21a,b	Me-I	
691	25c,e	Me-I	Me-4a
691	5b	Gn	
692	14	Sa-I	
701	10	Lw-II	
701	13	Lw-II	Lw-1b
701	25e	Me-I	
702	18	Lw-II	Lw-3b
704	10	Ka-I	Ka-4b
704	29a	Ka-II	Ka-2,4c
721	19	Co-I	Co-2a
722	15a,b	Sa-II	Sa-2b
723	23	Me-III	Me-5d
724	16	Gn	Vo-5c
724	23	Me-III	Me-5d
725	14	Sa-I	Sa-4
726	22a	Se	
727	22b	Se	
728	8	La-I	La-1,3
730	11	La-II	La-2
732	4b	Vo-II	Vo-5a,6
734	21a	Me-I	
734	4a,b	Vo-II	Vo-5a,5a,6
735	26	Me-II	
735	21a,b	Me-I	Se-3b
735	25c,e	Me-I	Me-4a,6b
735	5b	Gn	
737	13	Lw-II	Lw-1b
738	21a	Me-I	Se-3b
738	22b	Se	Se-1,3a
740	18	Lw-II	Lw-3b
751	28	Me-III	Me-5b
761	28	Me-III	Me-5b
762	16	Gn	Vo-5c
763	25e	Me-I	
763	5b	Gn	
764	22a	Se	Se-2
766	21b	Me-I	Se-3b
767	11	La-II	La-2,4a
771	8	La-I	La-3,4b
772	21a	Me-I	Se-3b
772	4b	Vo-II	
781	23	Me-III	Me-5d
782	4a,b	Vo-II	Vo-6
783	10	Lw-II	
783	13	Lw-II	Lw-1b
784	29a	Ka-II	Ka-2,4c
785	17	Lw-I	
786	7c	Ka-I	
787	10	Ka-I	Ka-4b

List of mapping units and correlation with farming system zones and groups, soil groups and agro-ecological zones														
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length growing season	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
AREAS WITH AN AVERAGE ANNUAL RAINFALL OF MORE THAN 1000 MM														
Cool, high, humid areas (A1)														
High to very high, humid to very humid, volcanic areas in Southern Highlands														
A1a1	MP1a	1a1	1a	Vo-1a	1600-2900	1000-1600	m	6-12	no data	Volcanic ash	PP7v	261b,473		Le,Fe,Er,SI
A1a2	MP1a	1a1	1a	Vo-1a	1600-2300	1500	m	6-12	I	Volcanic ash	PP7v	261b		nd
A1b	MP1a	2a2	1b	Vo-1a	1500-2600	1000-2000	m	8-12	I	Basalt, volcanic ash	P4v	133,265,275,364		nd
A1c	MP1a	1a1 (2a2)	1a,1b	Vo-1a	1900-2100	1400	m	6-12	I	Volcanic ash	Uben/Moc,PP7v,PI4	145,261b		nd
High to very high, humid to very humid areas in Southern Highland on gneiss														
A1d1	MFo1a	2c2	5a	Gn-1b		1000-1600?	m		I	Gneiss	Uben	111,146,272		nd
A1d2	MFo1a	2c2	5a	Gn-1b	1500-2800	1400	m	no data	I	Gneiss	Moc	111		nd
High to very high, humid, dissected Eastern Iringa highlands on gneiss														
A1d3	MP2	2c2	5a	Gn-1b	1700-2200	1000-1400	m	5-7	I	Gneiss	Moc	272,362?		Fe,Wo,Er
Intermediate to high, humid to very humid Mahenge highlands on gneiss														
A1d4	MB2	2c2	5a	Gn-1b	800-1700	1000->1500	t	6.5-9.5	m	Gneiss	Moc	111,272,363,461		Er,Ac,De,Dg,Wo,SI
Intermediate to high, humid to very humid Western Usambara (Lushoto) highlands on gneiss														
A1d5	MB2	2c2	5a	Gn-1b	800-2000	1000->1500	b	5-6.5-12	m	Gneiss	Moc	111,272,363		Wo,Er,De,Ac,Dg,Om,SI
Intermediate to high, humid Eastern Usambara highlands on gneiss														
A1d6	MB2,tea	2c2	5a	Gn-1b	800-2000	1000-1300	b	9-12	m	Gneiss	Moc	111,272,363,412		Er,Fe
Intermediate to high, humid to very humid Morogoro highlands on gneiss														
A1d7	MB2	2c2	5a	Gn-1b	500-2000	1000->1500	t	5.5-7	m	Gneiss	Moc	111,272,363,412		Er,SI,Dg,Wo
High, humid Kigoma highlands on basalts, argillaceous sandstone, limestone, phyllite, quartzite														
A1e	CMB2	1a2	7a	Ka-1	1500-1700	1000-1500	m-t	6-8	I	Sandstone, limestone	Buk2	367,479		Fe,Ac,Er
A1f	CMB2	2b2	7c	Ka-1						Phyllite, quartzite	KA2	108,116,276,365,367,479		
High, humid west Njombe plateau on granite and gneiss with volcanic ash cover														
A1g1	MP1a	1a1	1a	Vo-1a	1800-2000	1000-1200	m	6-9	I	Volcanic ash	PPv7/Moc	261b		nd
A1g2	MP1a	1a1	1a	Vo-1a						Volcanic ash		265		
High, humid to very humid, volcanic Rungwe highland in Southern highlands														
A1h1	CB1	2a2	1b	Vo-1b	600-2000	>1000	m	6-12	I	Basalt, volcanic ash	P4v/Moc?	265,275,364		Le,Fe,Er,SI
A1h2	CB1	2a2	1b	Vo-1b	600-2000	1000-2600				Basalt, volcanic ash	P4v	265		
High, humid to very humid Rungwe highland in Southern highlands on gneiss														
A1h3	CB2	2a1	3	Gn-1a						Gneiss	Uben	275,364		
Intermediate to very high, humid Mwese-Mpande range on acid metamorphic rocks (gneiss)														
A1i	MB2	2b3	25c	Me-1	1100-2500	1200-1300	m	6-8.5	I	Gneiss	Uben	335,364,421,473,506?		Fe,Er
Intermediate to high, humid Matengo highlands, Wino ward on gneiss														
A1j1	CMB3a	2c2	5a	Gn-1b	1300-1600	1200-1500	m	6-9	I	Gneiss	Moc	272		Wo,Er,SI
Intermediate to very high, humid areas in Southern Highlands on gneiss														
A1j2	MB2	2c2	5a	Gn-1b	1000-2200	1000-1300	m	no data	I	Gneiss	Moc	272,362?		nd
Intermediate to high, humid Ludewa plateau on gneiss														
A1j3	MP2	2c2	5a	Gn-1b	1000-2000	1000-1200	m		I	Gneiss	Moc	272		
High, semi-humid to humid Meru-Kilimanjaro volcanic ash footslopes														
A1k1	CB1	2c1	4a	Vo-1c	900-3500	1000-2000	b(-t?)	5-11	I(-m)	Volcanic ash	PP8v	271,321	782	Er, Ac,Om,De
A1k2	CB1	2c1	4a	Vo-1c			b(-t?)			Volcanic ash	Subr3v	262		
Intermediate, humid areas (A2)														
Intermediate to high, humid to very humid Bukoba and Muleba high rainfall area on sedimentary and metamorphic rocks (sandstone, shale)														
A2a1	CB3,tea	2b1	29a	Ka-2	1200-1600	1000/1200-2100	b	7-12	I	Sandstone, shale	Buk2	341,368,391?		Fe,Ac,Dn,Le
A2a2	CB3	2b1	29a	Ka-2	1150-1400	1000/1200+	t-b	9-12	I	Sandstone, shale	Buk2	108,341,391	704,784	Fe,Ac
Intermediate, humid Northern Sengerema, Ukerewe and Western Mara on granite														
A2b	MCCR	2g1	25e	Me-2b	1200-1300	1000-1200	b	4-5	m?	Granite	BC	111,335a,381,421a		Fe,Dr,Wo,Ac
Intermediate, humid Karema depression on alluvial and lacustrine sediments and gneiss														
A2c	MB2	2b3	25c	Me-2a	1000-1300	1200	m-t	6-9(5-7?)	I	Gneiss	Uben	473, 364?		Fe,Sa,So,FI
Low to intermediate, humid Mbinga area on gneiss														
A2d1	MB2	2c2	5a	Gn-2	500-1500	1000-1500	m	6-9	I	Gneiss	Moc	272		Wo,Er,SI
Intermediate to high, humid Lupemba-Niave hills on gneiss with volcanic ash influence (?)														

A2d2	MP2	2c2	5a	Gn-2	900-1600	1600	t	5-9	m	Gneiss	Moc	363,412		Er,Le(E7:Fe,Ac)
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length growing season	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Humid Songea plateau and Madaba-Mahanje area on gneiss														
A2d3	MB2	2c2	5a	Gn-2	750-1000	1000-1400	m	5-7	l	Gneiss	Moc	362,412,421		Fe,Ac,(Er),Wo?
Low, humid lake Nyasa shore on gneiss and sediments														
A2d4	CR	1b1	25b?	Me-2a		1200	m	8-12	l	Schist, gneiss	Moc	272?		
Low, humid Ruhuhu escarpment shallow soil area on gneiss														
A2d5	MFo1a	2c2	5a	Gn-2	700-1000	1200	m?	5-7	no data	Gneiss	Moc	111		nd
Low, semi-humid south-eastern Songea plain on gneiss														
A2d6	MB2,C1	2c2 (2i1)	5a	Gn-2	500-800	1000		5-7		Gneiss	Moc	362,412		
Humid granite hills on Songea plateau														
A2d7	MB2	2c2	5a	Gn-2	750-1000	1000-1400	m	5-7	l	Gneiss	Moc	111,421		Fe,Ac,(Er),Wo?
Low, humid lake Tanganyika shore areas on schist and granite														
A2e	CR	1b1	25b	Me-2a	500-1000	1000-1500	m	5-7	l	Schist, granite	KA1	106?,475?		Fe
Low, semi-humid south-eastern Songea plain on sandstone														
A2f	C1	2i1	14	Sa-1	500-800	1000		5-7		Sandstone, shale	Kar	342		
Low, humid west Kyela rocky terrain on sandstone and shale														
A2g	MFo1a	2i1	14	Sa-1						Sandstone, shale	Kar	110		
Warm, low, humid areas (A3)														
Low to very low, humid Kyela plain on lacustrine and alluvial sediments														
A3a	RC	1c1	9	Me-2c	500	1000-2600	m	8-12	l	Lake deposits	Rec2	206	647	Fl
Very low, humid Zanzibar-Pemba-Mafia islands														
A3b	CT	2j1	27	Co-1b	<200	1000-1300	b	4-5,1.5-2.5	b	Coastal sand and clay	PP1	331		nd
A3c	CT	2e1	19	Co-1a	100	1000-1200		5-10	m	Limestone, marl, clay	Pleist2	144,401,522		
AREAS WITH A+A211N AVERAGE AT LEAST 700 MM ANNUAL RAINFALL														
Cool, high, semi-humid areas (B1)														
High, semi-humid Karatu plateau, Oldeani volcanic ash area														
B1a1	MP1b	2c1	4a	Vo-3	1500?-2500	800->1000	t-b	3-5	l-h	Volcanic ash	PP8v	271,321		Er,Dr
B1a2	MB1b	2c1	4a	Vo-3						Volcanic ash	PP8v	102,141,271	782	
High, semi-humid to humid Mufindi and Kidugala plateau on gneiss														
B1b1	MB2,MP2	2c2	5a	Gn-3	1700-2000	900-1200	m	5-7	no data	Gneiss	Moc	272,473		Fe,Om
High, semi-humid to humid East Njombe plateau on gneiss														
B1b2	MP2,tea,wattle	2c2	5a	Gn-3	1500-1800	900-1200	m	6-9	l	Gneiss	Moc	272,473		Fe,Dr,Om
High, semi-humid to humid Pare mountains on gneiss														
B1b3	CB2,MB2	2c2	5a	Gn-3	1500-2000	800->1000	m	5-12	?	Gneiss	Moc	111,272,363		Er,Fe
High to very high, humid Mpwapwa plateau on gneiss														
B1b4	MP2	2c2	5a	Gn-3	1500-2300	>1000	t	5-7	m	Gneiss	Moc	272,338,461,473		Fe,Wo,Er
High to very high, humid Eastern Ubena plateau on gneiss														
B1b5	MB2	2c2	5a	Gn-3	1100-1700	1000-1300	m			Gneiss	Moc	272,473		
Very high, semi-humid Northern Ubena plateau on gneiss														
B1b6	MB2	2c2	5a	Gn-3	1600-1800	900-1000				Gneiss	Moc	272,473		
High to very high, semi-humid to humid Kate-Mwazye hills and Nkungwe mountain on schist and granite														
B1c	MFm1a	1e1	25a	Me-3	1500-2300	850-1200	m	5-9	l	Schist, granite	KA1	115,339,422,475,504		nd
Intermediate to high, semi-humid to humid Mbozi plateau on gneiss with volcanic ash cover														
B1d	CMB1,coffee	1d2	2	Vo-2	1200-1800	800-1200	no data	6-9	no data	Gneiss, volcanic ash	(PP8v)/Uben	264,478		nd
Intermediate, semi-humid to humid Kasuli-Kibombo medium altitude western plains on basalt, limestone and sandstone														
B1e	MB3	1d1	7b	Ka-3a	1000-1500	800-1400	m-t	6.5-8	l	Basalt, limestone, sandstone	Buk1	276,367		Er,Fe,Dr
Intermediate, semi-humid to humid Nkansi-Kasanga plain on sandstone														
B1f	CR	2b1	29a	Ka-3b	1000+?	900-1200				Sandstone, shale	Buk2	477		
Intermediate, semi-humid areas (B2)														
Intermediate to high, semi humid Yambamrizi range and Ipumba hills on gneiss														
B2a1	MFm1a	1e1	25a	Me-4a	1000-2000	900-1000	m	5-7	l	Gneiss	Uben	111,421,473		nd

B2a2	MFm1a	1e1	25a	Me-4a					Gneiss	Uben	210,339	651		
Intermediate to high, semi-humid to humid Meru-Kilimanjaro volcanic ash plains														
B2b1	MB1a	2c1	4a	Vo-3	900-2000	800-1200	b	3-6	h	Volcanic ash	Subr3v	231,262	734	Dr,Er,Dg
B2b2	MB1a	2c1	4a	Vo-3			b		h	Volcanic ash	PP8v	271,321	782	
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Intermediate to high, semi-humid to humid, shallow soil areas in Southern Highlands on gneiss														
B2c	MB2	2c2	5a	Gn-3	500-1600	900-1300	no data	no data	no data	Gneiss	Moc	111		nd
Low to high, semi-humid to humid Uruwira plain on gneiss														
B2d1	TP1a	2g1	25e	Me-4a	850-1600	900-1200	m	5-6	l	Gneiss	Uben	335,501		Er,Fe
Intermediate to high, semi-humid to humid, shallow soil areas in Southern Highlands														
B2d2	MFm1b	2d2	25d	Me-4a	1500-1800	1000	m	4-6.5	l-m	Gneiss	Uben	335,421,477,501		Fe
Intermediate, semi-humid to humid Western plateau on intermediate and basic gneiss														
B2d3	MB2	2b3	25c	Me-4a	1100	900-1200	m	5-6	l-m	Gneiss	Uben	335,473		Fe,Fl
Intermediate, semi-humid Inyonga plain, Kipembawe plain on gneiss														
B2d4	MS2b	2b3	25c	Me-4a	1000-1200	900-1000	m	5-6	l-m	Gneiss	Uben	335,473		Fe,Fl
Intermediate, semi-humid to humid Northern Kagera floodplain on alluvial/colluvial sediments from schist and granite														
B2e1	ML1a,s/cane	2h1	10	Ka-4b	1000-1500	800-1500	b	9-12	l	Stream deposits	Subr2	203,652	704,787	Fl,Fe,Ac
Intermediate, semi-humid to humid Mara floodplain on granite and sediments														
B2e2	ML1b	2h1	10	Lw-2b	1150-1400	800-1200	b	4-5	m?	Stream deposits	Subr2	202	642	nd
Intermediate, semi-humid to humid Katumba plateau on sandstone, shale and quartzite														
B2f1	TP1a	2b1	29a	Ka-4c	1000-1500	900-1200	m	6-7.5	no data	Sandstone, shale, quartzite	Buk2	341,477		Fe
Intermediate to high, semi-humid Central Biharamulo area on sandstone														
B2f2	B	2b1	29a	Ka-4c	1200-1600	800-1000	t?	4-5	no data	Sandstone	Buk2	341,391	704,784	Fe,Ac,Dr
Intermediate to high, semi-humid Busando hills on sandstone and shale														
B2f3	TP1a	2b1	29a	Ka-4c	1000-1700	950	m	5-6?		Sandstone, shale	Buk2	106,477,506		
Intermediate, semi-humid south-western Kagera plains on sandstone and shale														
B2f4	CB3	2b1	29a	Ka-4c	1150-1400	800-1000/12	t-b	6-7.5	l	Sandstone, shale	Buk2	106,368		Fe,Ac
Intermediate to high, semi-humid Karagwe plains and hills on phyllite, quartzite, schist and granite														
B2g1	CB3	2b2	7c	Ka-4a	1300-1800	800-1000	b-t	7-9	l	Phyllite, quartzite	KA2	108,116?,365		Fe,De,Er
B2g2	B	2b2	7c	Ka-4a						Phyllite, quartzite	KA2	106,108,365		
B2h	CMB2,ML1d	2d1	17	Lw-2a	1000-1500	800-1000				Schist, granite	KA1	115,366		
Intermediate to high, semi-humid, shallow soil areas in Southern Highlands on gneiss														
B2i	MF01a	2c2?	5a?	Gn-3	1000-1800,	900	m	8-10	no data	Gneiss, volcanic ash?	PI4v	261b,265		nd
Intermediate, semi-humid Bukombe-Kahama plateau on granites and intermediate and basic gneiss														
B2j1	MGTP	2g1	25e	Me-4a	1100-1300	800-1000	t-m	4-6	l-m	Gneiss, granite	Dod	335,421		Fe,Fl
B2j2	MGTP	2g1	25e	Me-4a	1100-1300	800-1000				Basic granite	BC ?	381		
Intermediate, semi-humid Tabora plains on granite and gneiss														
B2j3	MGTP	2g1	25e	Me-4a	1000-1200	700-900	m	4-5	l-m	Gneiss, granite	Dod	335,421		Fe,Ac,De
B2j4	MGTP	2g1	25e	Me-4a		800-900				Gneiss, granite	Dod	111		
Intermediate, semi-humid Sukumaland plains on granites and sediments														
B2k	MGTP	2g1	25e	Me-4a	1200-1300	800-1000	t	4-5	l-h	Granite	BC	335,421	691,735	Fe,Dr,Wo,Fl,Ac
B2l1	CM1a	2h2	18	Lw-2c	1000-1200	800-1000	t	3-3.5	l-h	Granite, gneiss, wash deposits	Pleist3	336,502	602	Fe,Dr,Wo
B2l2	RL	2l2	8	La-1	1000-1200	800-1000				Wash, lake, stream deposits	PP3		602,728	
Intermediate, semi-arid to semi-humid, south-eastern Bukombe and Sikonge-Msisi plains on granite and gneiss														
B2l3	MSP2	2h2	18	Lw-2c	1100	800	m	5-6	l-m	Granite, gneiss, wash deposits	Pleist3	336,423		Dr,Fe
Intermediate, semi-humid Mbuga soil dominated eastern and western Sukumaland														
B2m	MCCR	2l1	22b	Se-1	1000-1200	800-1000	m-t	3-3.5	l-m	Stream deposits	Subr2		738	Wo
Low to intermediate, semi-humid western (Tabora, Kibondo, Urambo) swamps on alluvial sediments														
B2o	RSp	1f1	13	Lw-1b	900-1200	800-1000	m	5-6(flood)	l-m	Lake, stream deposits	Rec2		671,701,737,783	Fl,Dn
Low, semi-humid Mahenge basin, Mkulula valley and Kilosa (west Mikumi) on gneiss														
B2p1	MSP1b	2m1	26	Me-4b	900-1000	800-1000	m	6-9	no data	Gneiss	Moc	363,412		nd
Low to intermediate, semi-humid Kilosa-west and Mpwapwa medium altitude plains on gneiss														
B2p2	CMB3b	2f1	5b	Gn-4	750-1500	800-1000	t?	3-5		Gneiss	Moc	272,338,461		
Low to intermediate, semi-humid Kilombero-Mahenge plain on gneiss														
B2r	CM1b	2m1	26	Me-4b	1000	800-1000	t-m	6-9	l-m	Gneiss	PP5	453,476,503		Fe
Low to high, semi-arid to humid Kigoma lowlands on sedimentary and metamorphic rocks														

B2s	CRO	1f2	20	Lw-1a	800-1800	600-1300	m	6-7.5	l	Limestone, basalt	Buk1	337,474		Fe
B2t	CRO	1f3	29b	Ka-4c	800-1800	800-1300	m	6-7.5	l	Sandstone, shale	Buk2/Uben	106,341,364,421,473,477		Fe,Er
Warm, low, semi-humid areas (B3)														
Very low to low, semi-humid to humid Kilombero valley on alluvial sediments														
B3a	RMC,s/cane	1g2	12	Sa-2c	400-600	900-1200	t	5.5-8(flood)	m	Stream deposits	Pleist1	205	611,633,648	Fl,Fe
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Very low, semi-humid to humid Rufiji valley on alluvial sediments														
B3b	RMC	1h3	28	Me-5b	<200	800-1200	t	3-4.5(flood)	l-m	Stream deposits	Rec1	201	641,751,761	Fl
Low, semi-humid, wet Eastern lowland footslopes on gneiss														
B3c1	CM1b	2m1	26	Me-4b	500-1000	800-1000	t-m	4-6.5	l-m	Gneiss	Moc	362,412		Fe,Wo,Er,De,Ac,Dg
B3c2	CM1b	2m1	26	Me-4b	500-1000	800-1000				Gneiss	Moc	335,412,473,362		
Low, semi-humid south Masisi semi-humid plain on acid gneiss														
B3c3	SML1a	2m1	26	Me-4b	400-500	800-1000	m	5-6	l	Acid gneiss	Moc	335,412,473		Fe
Low, semi-humid Nachinwea plain on intermediate gneiss														
B3d1	MSe1a	2m1	26	Me-4b	500-600?	800-1000	m	5-6	l	Gneiss	PP5	363,453,503		Fe
Low to very low, semi-humid, south-eastern Tunduru and western Nachinwea plain on gneiss														
B3d2	MSe1a	2m1	26	Me-4b	<600	800-1000	m	5-7	l	Gneiss	PP5	453,476,503		Fe
Very low to low, semi-humid sedimentary plateau in Southern and Eastern zone on shale and sandstone														
B3f	C1,C2	2i1	14	Sa-2a	600-1100	600-1000	m-t	4-6.5,5-7	l(-m)	Sandstone, shale	PP4	340,342		Fe,Dr,Om
Very low, semi-humid Makonde plateau on sandstone, limestone and shale														
B3g1	C1,CCC	2n1	15b	Sa-2b	200-500	800-1000	m-t	3-4.5	l-m	Sandstone, limestone, shale	JP	541	674	Fe,Ac
Very low, semi-humid, Southern hinterland hills and plains on sandstone, limestone, shale														
B3g2	CCC	1g1	15a	Sa-2b	100-200?	800-1000	m-t	3-4.5	l-m	Sandstone, limestone, shale	JP	107,112,236,541	674,722	Sa,Fe,Wo
Very low, semi-humid, Eastern hinterland hills and plains on sandstone, limestone, shale														
B3g3	CCC	1g1	15a	Sa-2b	<200	800-1000	b	3-4.5, 1-2	l-h	Sandstone, limestone, shale	JP	541	674	Fe,Dr,Wo
Low to very low, semi-humid Eastern plains on metamorphic rocks and alluvial sediments														
B3h1	CM1b	2m1	26	Me-4b	250-1000	800-1000	t	4.5-6	m	Gneiss	Moc	335,412,473		Ac,Fe
Very low to low, semi-humid Muheza plains on intermediate gneiss														
B3h2	MS2a,sisal	2m1	26	Me-4b	150-500	1000	b	3-4.5,2.5-3	l-m	Gneiss	Moc	362,412		Fe,Ac
Very low, semi-humid to humid coastal floodplains and deltas														
B3i	RMC	1h3	28	Me-5b	<100	1000	b	3-4.5(flood)	?	Stream deposits	Rec1	201	621,641	nd
Very low, semi-humid Eastern plains on alluvial sediments														
B3j1	RMC,sisal	1h1	23	Me-5d	400-500	800-1000	t	(4-6.5)	m	Stream deposits	Subr1		632,724,781	(Fe,Ac),Dr,Fl
B3j2	RMSp	1h1	23	Me-5d	<500	800-1000	t	3-4.5	m	Stream deposits	Subr1	332,521	601,723	Fe,Fl
Very low, semi-humid, Eastern and Southern hinterland hills and dissected uplands on old sedimentary rocks														
B3k	MSP2,citrus	1h2	24	Co-3a	200	800-1000	?	3-4.5	?	Coastal sand and clay	PP2	471,472		?
Very low, semi-humid, Eastern and Southern hinterland plains on old sedimentary rocks														
B3l1	C1	2j1	27	Co-2b	<100-200	800-1000	m-t	3-4.5	l-m	Coastal sand and clay	PP1	331,451		Fe
Very low, semi-humid, Eastern hinterland plains on Quarternary and Tertiary sediments														
B3l2	MS2a	2j1	27	Co-2b	<200	800-1000	b	3-4.5, 1-2	l-h	Coastal sand and clay	PP1	331		Fe,Dr,Wo
Very low, semi-humid, Southern and Eastern coastal plains on Quarternary sediments														
B3m1	MS2a,sisal	2e1	19	Co-2a	<200	800-1000	b	3-4.5, 1-2	l-h	Limestone, marl, clay	Pleist2	522	675,721	Fe,Dr,Wo,Sa
B3m2	RCC,sisal	2e1	19	Co-2a	<100	800-1000	m-t	3-4.5	l-m	Limestone, marl, clay	Pleist2	522	675,721	Fe,Sa,Wo
AREAS WITH AN AVERAGE AT LEAST 500 MM ANNUAL RAINFALL														
Cool, high, semi-arid to humid areas (C1)														
High, semi-humid to humid Tarime highlands on lavas (phonolites) and granite														
C1a	MS1	1i1	6	Vo-4b	1500-1800	800-1200+	b	6-10	l-h	Volcanic phonolites	Miocene	273,361,411		Fe,Dr
High, semi-arid hills and mountains north of Mbeya and around Mbozi plateau on gneiss														
C1b	MFo1b	2a1	3	Gn-5a	800					Gneiss	Uben	111,473	682	
Intermediate to high, semi-arid to humid Mbeya stepped plain on volcanic ash														
C1c	MB4c	2a2	1b	Vo-4a	1200-1900	600-1500	m	6-9	l	Basalt, volcanic ash	Pleist4v	265		nd
Intermediate, semi-humid, upper Lukosi valley on gneiss														
C1d1	MB4a	2c2	5a	Gn-5b	1300-1400	900	m	5-6	l	Gneiss	Moc	111,272,473		Fe,Dr,Om?
Intermediate, semi-humid, lower Mufindi plateau on gneiss														

C1d2	MB4a,SF1	2c2	5a	Gn-5b	1200-1500	900		5-6		Gneiss	Moc	111,272		
Intermediate to high, semi-humid, shallow soil Usanga flat border area on gneiss														
C1d3	SF1	2c2	5a	Gn-5b	1000-1800	900	m	5-7	l??	Gneiss	Moc	111		Fe,Dr,Om,Er,Le
Intermediate, semi-arid to semi-humid areas (C2)														
Intermediate to high, semi-arid to humid Chunya dissected plain on gneiss														
C2a1	TP1a	2g1	25e	Me-5a	1200-1800	700-1300	m	4-6	l	Gneiss	Uben	111,421		Fl,Fe(?)
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length growing season	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Intermediate to high, semi-arid to semi-humid, shallow soil areas in Southern Highlands														
C2a2	MFm1b	2d2	25d	Me-5a	1000-1700	750-900	m	5-7	no data	Gneiss	Uben	111		nd
Low to intermediate, semi-arid to semi-humid East Handeni, north Morogoro hilly plains and footslopes on gneiss														
C2b	MSP1a	2f1	5b	Gn-5c	750-1500	600?-1000				Gneiss	Moc	237,363,412,461		
Low to intermediate, semi-arid to humid Rukwa valley/floodplain on alluvial and lacustrine sediments														
C2c1	TP1b	2o1	11	La-2	800-1200	600-1200	m	5-9	l-m	Lake, stream deposits	Rec2	343,414,425,509	634,730,767	So,Fl,Sa,Fe
Low to intermediate, semi-arid to humid Rukwe/Songwe valley on alluvial sediments														
C2c2	TP1b	2o1	11	La-2	800-1200	750-1200	m	5-6	l?	Stream deposits	Rec2	343,414,425,509	767	So
Intermediate, semi-humid, Songwe-Msangano-Itumba through area on recent deposits														
C2c3	MSP5	2o1	11	La-2	1000-1500	900-1200	no data	no data	no data	Stream deposits	Rec2	109,343,509	605,634,767	nd
Low, semi-arid to (semi)-humid Ruhuhu valley lowlands on alluvial and lacustrine sediments (sandstone, shale)														
C2d1	MB4b	2i1	14	Sa-3a	500-900	600-1200(90)	m	5-9	l	Sandstone, shale	Kar	342,527		nd
Low to intermediate, semi-humid dissected sedimentary plateau in Southern zone on shale and sandstone														
C2d2	C2	2i1	14	Sa-3a	200-1000	800-900	t-m	5-7	l-m	Sandstone, shale	Kar	342		Fe
Low, semi-arid to semi-humid west Serengeti area on granite and gneiss with volcanic ash cover														
C2e	P1a	2k1	4b	Vo-4c	<1000	600-1000				Volcanic ash	PP7v	232,252	732	
Low to intermediate, semi-humid sedimentary plateau in Southern zone on shale and sandstone														
C2f	MSe1b	2i1	14	Sa-3a				5-7		Sandstone, shale	PP4	340		
Warm, semi-humid areas (C3)														
Very low to low, semi-humid Eastern plains on intermediate gneiss														
C3a1	MS2a,sisal	2m1	26	Me-5c	200-1000	800-1000	t-b	3-4,1-2	m	Gneiss	Moc	362,412		Fe,Ac,Dr
C3a2	CM1b	2m1	26	Me-5c	500-1000	800	t-m	<4-6.5	m	Gneiss	Moc	362,412		Fe,Wo,Er,De,Ac,Dg
Very low, semi-arid to semi-humid Southern plains on intermediate gneiss														
C3b	MSe1a	2m1	26	Me-5c	<500	750-900	t-m	3-5	l-m	Gneiss	PP5	334,363,413,452,453,476,503		Fe
C3c	MSe1a	2m1	26	Me-5c	<500	500-1000				Gneiss	PP5	413,473		
Very low, semi-arid, Eastern hinterland hills and plains on sandstone, limestone, shale														
C3d	MS2a,CCC,sisal	2n1	15b	Sa-3b	<200	800	b	<3-4.5, 1-2	m-h	Sandstone, limestone, shale	JP	541	674	Fe,Dr,Wo
Very low, semi-arid, Eastern hinterland hills and dissected uplands on old sedimentary rocks														
C3e	MSP2	1h2	24	Co-3a	200	800	?	<3-4.5	?	Coastal sand and clay	PP2	471		?
Very low, semi-arid, Eastern and Southern hinterland plains on old sedimentary rocks														
C3f	RCC	2j1	27	Co-3b	<100-200	800	m-t	<3-4.5	m	Coastal sand and clay	PP1	331		Fe
Very low to intermediate, semi-arid dissected sedimentary plateau in Eastern zone on shale and sandstone														
C3g	C2, C1	2i1	14	Sa-3a	200-1000	800	t-m	<5-7	m	Sandstone, shale	Kar	342		Fe
Very low, semi-arid Eastern plain on alluvial sediments														
C3h	RMSp	1h1	23	Me-5d	<500	800	t	<3-4.5	m	Stream deposits	Subr1	332,521	723	Fe,Fl
Very low, semi-arid Rufiji valley on alluvial sediments														
C3i	RMC	1h3	28	Me-5d	<200	800	t	<3-4.5(flood)	m	Stream deposits	Rec1	201	641,751,761	Fl
Cool, high, semi-arid to semi-humid areas (D1)														
Intermediate to high, semi-arid to semi-humid Namanyere-Laela plain on gneiss														
D1a	MFm2	2d2	25d	Me-6a	1200-1700	750-950	m	5-6.5	l-m	Gneiss	Uben	210,335,421,477,501	651	nd
High, semi-arid to semi-humid Iringa plain on gneiss														
D1b1	MB4a,SF1	2c2	5a	Gn-6a	1500-1700	600-900(720)	m	5-6	l?	Gneiss	Moc	272,473		Fe,Dr,Om
High, semi-arid dissected west Iringa plain on gneiss														
D1b2	MB4a,SF1	2c2	5a	Gn-6a	1500-2000	600-800				Gneiss	Moc	111,473		
Intermediate, semi-arid commercial ranching area in central-northern Kagera on schist and granite														

D1c	ML1d	2d1	17	Lw-3a	1000-1500	800	b	no data	l-m	Schist, granite	KA1	115,366		nd
High, semi-arid, eastern Mbulu area on gneiss														
D1d1	WBMBP,MB5a	2c2	5a	Gn-6b	1500-2500	500-800	t-b	3-5	l-h	Gneiss	Moc	273?		Fe,Wo,Er
D1d2	WBMBP	2f1	5b	Gn-6b	1500-2500	500-800				Gneiss	Moc	131,273?,421		
High, semi-arid Serengeti plain														
D1e	Park1a,P1a	2k1	4b	Vo-5a	1000+	600-800				Volcanic ash	PP7v	232,261a		
Intermediate, semi-arid areas (D2)														
Intermediate, semi-arid to semi-humid south-eastern Babati, northern Kondoa area on gneiss														
D2a1	MB5b	2f1	5b	Gn-6b	1200?	600-900	b?	2-2.5	h	Gneiss	Moc	461		Er,Fe,Dr
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length growing season	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Low to intermediate, semi-arid to semi-humid Usambara footslopes on gneiss														
D2a2	MB5b,MSP4	2m1	26	Me-7	500-1200	600-1000	b	2-2.5?	l-h	Gneiss	Moc	412,461		nd
Intermediate, semi-arid to semi-humid Chunya plain, Wago hills on gneiss														
D2b1	MSP3	2g1	25e	Me-6b	1000-1500	700-900	m	4-5	l-m	Gneiss	Uben	335,473		Fe,Dr
D2b2	MSP3	2g1	25e	Me-6b	1000-1500	700-900				Gneiss	Uben	111,131,381,421		
Intermediate, semi-arid North Iringa shallow soil hill range on granite and gneiss														
D2c	MSP3	2g1	25e	Me-6b	1000-1500	600-700				Granite, gneiss	Dod	111,131,335,421		
Intermediate, semi-arid Karagwe (central and north-western Kagera) plains and hills on schist and granite														
D2d	ML1d	2d1	17	Lw-3a		800	?	7-12??		Schist, granite	KA1	115,116,366		
Intermediate, semi-arid Kondoa, Kibaya, west Handeni hills on gneiss														
D2e	MB5b,MSP3	2f1 (2g1)	5b	Gn-6b	1400-1500	600-800				Gneiss	Moc	461		
Intermediate, semi-arid Mpwapwa and east Kondoa plains on gneiss														
D2f	MSP3	2g1	25e	Me-6b	1000-1300	550-800				Gneiss	Moc	461	735	
Low to intermediate, semi-arid to semi-humid Northern lowlands on gneiss without volcanic sediments														
D2g	MBP,bean	2f1,(2c1)	5b,(4a?)	Gn-6b	500-1200	500-1000	b	2-?	m-h	Gneiss	Moc	461	735	Er,Sa,Dg
Low to intermediate, semi-arid to semi-humid Northern lowlands on gneiss with some volcanic sediments														
D2h1	Park1a,P1a	2k1	4b	Vo-5a	500-1200	800				Volcanic ash	Subr3v	231,251	734	
D2h2	MBP	2c1	4a	Vo-5b	500-1200	550-1000				Volcanic ash	Subr3v	231	734	
D2h3	Park1a	2k1	4b	Vo-5a	<1000	700-800				Volcanic ash	PP7v	252	732	
Low to intermediate, semi-arid to semi-humid Gumbiro area on sandstone and shale														
D2i	MB4b	2i1	14	Sa-4	800-1200	600-1000	m	5-6	l	Sandstone, shale	Kar	342,527	725	Fe,Dn
High, semi-arid Hanang area on volcanic ash														
D2k1	WBMBP,	2c1	4a	Vo-5b	1500	800	t	2-4(3-5?)	m-h	Volcanic ash	Subr3v	231		Er,Dr
D2k2	Bare	none,(2c1)	4a	Vo-5b	1500	800				Volcanic ash	Subr3v	101,142,231		
Intermediate to high, semi-arid Northern plains on volcanic ash														
D2k3	MBP	2c1	4a	Vo-5b	1300-1700	<800	t	2-3.5	m-h	Volcanic ash	Subr3v	262		Fe,De,Ac?,Er,Dr
High, semi-arid Babati area over gneiss and possibly with some volcanic ash														
D2k4	WBMBP	2f1 (2c1)	5b,(4a?)	Gn-6b						Gneiss, volcanic ash?	Moc or SR3v?	231,461		
D2l	MBP,s/cane,	2c1	4a	Vo-5b	1300-1700	<800	b?	2-3.5	l-h	Volcanic ash	PP8v	321		Er,De,So
Intermediate, semi-arid Pare mountain footslopes on intermediate gneiss														
D2m1	MB5b	2f1	5b	Gn-6b	1200-1500	500-800	b	2-4.5	h	Gneiss	Moc,Subr2	362,412,461		Er,Fe,Dr
D2m2	MB5b,sisal	2f1	5b	Gn-6b	1300-1700	500-800				Gneiss	Moc	412,461		
Intermediate, semi-arid Meatu-Maswa, Shinyanga areas on granite (basement complex)														
D2n	CSP	2g1	25e	Me-6b		600-800		3-3.5		Granite	BC	335,421		
Intermediate, semi-arid Ibushi plain on marl, sandy and clayey sediments														
D2o1	CS	2l2	8	La-3	1000-1100	500-800	m-t	3-3.5	l	Wash, lake, stream deposits	PP3	238		Er,Dg
East Lake Manjara shore on old lacustrine sediments														
D2o2	P2b	2l2	8	La-3		600-800				Wash, lake, stream deposits	PP3	234,462	731,771	
Intermediate, semi-arid Shinyanga-Igunga area on metamorphic rocks and sediments														
D2o3	CSP	2l2	8	La-3		600-800		3-3.5		Wash, lake, stream deposits	PP3		602,738	Dg,Er
D2p1	CSP	2l1	22b	Se-2		600-800		3-3.5		Lake, stream deposits	Subr2	239	604	Dg,Er
Intermediate, semi-arid Pangani river lowlands on alluvial sediments														
D2p2	RMSp	1j1	16	Vo-5c		500-600		<2,flood	m	Stream deposits	Subr1 (3v?)		724,762	Sa,So,Wo
Intermediate, semi-arid Northern Kagera floodplain on alluvial/colluvial sediments from schist and granite along Ruanda border														
D2p3	ML1c	2h1	10	Ka-4b	1000-1500	700-800	b	9-12	l	Stream deposits	Subr2		704,787	Fl,Fe,Ac

Intermediate, semi-arid Central and Northern plains on granites and gneisses														
D2q1	MGL	2g1	25e	Me-6b	1100-1300	600-800	m	2-2.5	l-m?	Granite, gneiss	Dod	335,381,421	735	Fe,De,Ac,Dg
D2q2	MGL	2g1	25e	Me-6b	1100-1300	600-800	m	3-3.5	l-m?	Granite, gneiss	Dod	335,421		Fe,De,Ac,Dg
D2q3	MGL	2g1	25e	Me-6b	1100-1300	600	m	2-2.5	l-m?	Granite, gneiss	Dod	111,131,335,421		Fe,De,Ac,Dg
D2q4	MGL	2g1	25e	Me-6b	1100-1300	600-800	m	3-3.5	l-m?	Granite, gneiss	Dod	111,131,421		Fe,De,Ac,Dg
D2r1	S	2h2, (2l2)	18	Lw-3b	1100-1300	700-800	m	4-5	l-m?	Granite, wash deposits	Pleist3	336,382,423,454		Fe,De,Ac,Dg
Intermediate, semi-arid Central-Western plains on continental deposits over granite														
D2r2	MGL	2h2	18	Lw-3b	1100-1400	500-600	m	3-3.5	l-m	Granite, wash deposits	Pleist3	336,454	740	Fe,Er,Dg,Dr
D2r3	MGL	2h2	18	Lw-3b	1100-1400	600-800	m	3-3.5	l-m	Granite, wash deposits	Pleist3	336,423,454	691,702,740	Fe,Er,Dg,Dr
Low, semi-arid, flooded or irrigated areas in Central on old alluvial sediments														
D2s	RSM	1j2	22a	Se-2	900	500-700	m-t	3-3.5 (var.)	l-h	Stream deposits	Subr2		604,764	Fe,Wo,Fl,Sa,So
Unit	FSZ	FSgroup	Soil group	AEZ	Altitude	Rainfall	Rainfall pattern	Length growing season	Drought risk	Geology (1)	Geology (2)	Upland soils	Hydromorphic soils	Main constraints
Warm, low, semi-arid to semi-humid areas (D3)														
Very low, semi-arid to semi-humid Eastern plains on intermediate gneiss														
D3a	SML1b,ranching	2m1	26	Me-7	300-400	700-1000	b-t	3-4,1-2	m-h	Gneiss	PP5	334,413,476		Fl,Dn,Dr
Very low to low, semi-arid Eastern plains on intermediate gneiss														
D3b1	MSP4	2m1	26	Me-7	200-750	500-800	t-b	3-4.5,1-2	m-vh	Gneiss	Moc	362,412,461		Fe,Ac
D3b2	MSP4	2m1	26	Me-7	500-1200	500-1000				Gneiss	Moc	412,461		
Low, semi-arid Southern plains on sandstone and shale														
D3c	Park1b	2i1	14	Sa-5	200-500	500-800	t	3-4.5	l-m	Sandstone, shale	PP4	340		Fe,Dr
AREAS WITH LOW RAINFALL														
Intermediate, arid to semi-arid areas (E)														
Intermediate, arid to semi-arid, southern Kwimbe- Northern Shinyanga area on old sediments														
Ea1	RP2	2i1	22b	Se-3a	1000-1200	400-800				Lake, stream deposits	Subr2		738	
Intermediate, arid to semi-arid south-west Eyasi area on old sediments														
Ea2	P2a	1k2	21a	Se-3b		400-600		3-3.5?		Lake, stream deposits	Subr2		738	
Intermediate, arid to semi-arid Kiteto, North Lushoto, North Monduli steppe on gneiss														
Eb1	P2b	2f1	5b	Gn-7	1000-1500	<500-600	b	<2	l-h	Gneiss	Moc	461	735	Er,De,So
Eb2	P2b	2f1	5b	Gn-7	1200?	550?				Gneiss	Moc	111		
Low, semi-arid Ruaha western lowland/valley on lacustrine and old alluvial sediments														
Eb3	MSP5	1k1	21b	Se-3b	700-900	550				Lake, stream, wash deposits	PP6	344,455,507	679,766	
Eb4	RP1	1k1	21b	Se-3b	700-900	550				Lake, stream, wash deposits	Dod+PP6?	111	766	
Intermediate, arid to semi-arid, southern Dodoma, western Iringa, north-western Lake Eyasi areas on granite and gneiss														
Ec1	MGL,MSP5,P2a	1k2, (1k1,2g1)	21a	Se-3b	1100-1300	400-600	m	3-3.5???	l-m?	Granite, gneiss, stream deposits	Dod	335,421	735	Fe,De,Ac,Dg
Ec2	Park1c	2f1	5b	Gn-7		500-600				Granite, gneiss	Dod	111		
Intermediate, arid to semi-arid, western Mbulu, northern Irambu area on granite and sediments (Basement complex)														
Ed1	P2b	2f1	5b	Gn-7	1100-1300	400-600	m	?	l-m?	Granite	BC	111,335,421	735	Fe,De,Ac,Dg
Ed2	P2a	1k2	21a	Se-3b		400-800				Granite, stream deposits	Subr2	335,343?,421,425?	724?,735	
Intermediate, arid to semi-arid Nduli-Ismani flats on recent sediments (over granite, gneiss)														
Ee1	MSP5,P2a	2o1 (1k2)	11	La-4b	1250-1500?	400-600	m	?		Stream deposits	Rec2	335,343?,425,509	605	
Low to intermediate, arid to semi-arid Usangu plain on recent alluvial or lacustrine sediments														
Ee2	RP1,rice	2o1	11	La-4b	750-1500	400-600	m	4-5,variable	l?	Lake, stream deposits	Rec2		605,634,767	Wo,Fl,Sa,Dn
Low, semi-arid eastern Ruaha lowland/valley on lacustrine and old alluvial sediments														
Ee3	MSP5	2o1	11	La-4b	700-900	550(-900)	m	3-3.5	l?	Lake, stream deposits	Rec2	204	647	Fe,Wo,So,Sa
Ee4	MSP5	2o1	11	La-4b	700-900	550				Lake, stream deposits	Rec 2	344,509	767	
Intermediate to high, arid to semi-arid, northern steppes on volcanic ash														
Ef1	Park1a,P1b	2k1	4b	Vo-6	?	400-600				Volcanic ash	PP7v	232,261a		
Ef2	P1b	2k1	4b	Vo-6		400-600				Volcanic ash	Pliocene	143,233,263	733	
Ef3	Park1a	2k1	4b	Vo-6		400-600				Volcanic ash	PPv8	102,141,235,271,321	782	
Ef4a	P1b	2k1	4b	Vo-6		400-600				Volcanic ash	Subrec 3v	102,142	734,772	
Ef4b	Bare	none	4b	Vo-6		400-600				Volcanic ash	Subrec 3v	102,142		
Ef4c	P1b	2k1	4b	Vo-6		400-600				Volcanic ash	Subrec 3v	262		
Ef5	P1b	2k1	4b	Vo-6		400-600				Volcanic ash	Subrec 3v	231	734	
Intermediate, arid, Lake Eyasi and Natron shore on lacustrine sediments														

Eg1	P2a	1k2	21a	Se-3b	400-500				Lake deposits	Subr2, 3v		772	
Eg2	P2b	2l2	8	La-4a	400-500				Lake deposits	PP3		771	