Radical Terraces
Rwanda - Amaterasi y’indinganire

Locally referred to as ‘radical terracing’, the method involves earth moving operations that create reverse-slope bench terraces which have properly shaped risers stabilized with grass or trees on embankment to avoid collapse.

In Rwanda, a unique method of back-slope terracing originally introduced by missionaries growing wheat in the Northern Province in the 1970s, has been widely adopted by smallholder farmers in many parts of the country. The farmers are careful to isolate the topsoil, then they re-work the subsoil to create the required reverse-slope bench, after which the topsoil is spread over the surface. The riser is planted with short runner grass for stabilization, all within the same day. Radical terraces have been constructed, the effects have been dramatic, achieving optimum water and soil conservation on slopes exceeding 50%, while adoption rates have been quite extensive. This high adoption of radical terracing is related to the existing policies and programs such as land consolidation, land management and crop intensification programs. These policies/programs boost the use of radical terraces by providing farmers more opportunities to easily access inputs such as improved seeds and manure for increasing the productivity of constructed radical terraces. Recent studies (e.g. Fleskens, 2007, Bizoza and de Graaff 2012 and Kagabo et al. 2013) assert that radical terraces in the highlands of Rwanda are only financially viable when the opportunity cost of labour and manure are below the local market price levels and when agriculture area on these radical terraces can be substantially intensified. Ten to 30 metric tons of manure (organic) are required to restore the soil fertility of newly established radical terraces.

In Rwanda, radical terraces are principally designed (1) to reduce soil losses through enhanced retention and infiltration of runoff, (2) to promote permanent agriculture on steep slopes and (3) to promote land consolidation and intensive land use. Newly established radical terraces should be protected at their risers and outlets, especially in the first or second year of the establishment. After establishing a terrace, a riser is shaped and grasses or shrubs/trees are planted soon after. Napier grass is commonly planted and is used as forage for livestock. Risers on radical terraces are seen as a new production niche of forage as a result of land shortage and a strict zero grazing policy. Radical terraces have the potential of improving farmers’ livelihoods and increasing the resilience of a degraded environment.

Classification

Land use problems:
- Soil erosion due to high runoff on the steep slopes, deforestation, intensive cultivation and lack of suitable land management methods. (expert's point of view)
- Low crop production, soil erosion and lack of fodder (land user's point of view)
Land use
Annual cropping
Perennial (non-woody)
cropping
rainfed

Climate
subhumid

Degradation
Soil erosion by water: loss of
topsoil / surface erosion

Conservation measure
vegetative: Grasses and
perennial herbaceous plants
structural: Bench terraces
(slope of terrace bed <6%)

Stage of intervention
Prevention
Mitigation / Reduction
Rehabilitation

Origin
Land users initiative
Experiments / Research
Externally Introduced
Other: Government: recent (<10 years ago)

Level of technical knowledge
Agricultural advisor
Land user

Main causes of land degradation:
Direct causes - Human induced: over-exploitation of vegetation for domestic use, overgrazing
Direct causes - Natural: other natural causes, Extreme topography: steep slopes in many cases over 50%
Indirect causes: population pressure

Main technical functions:
- control of concentrated runoff: retain / trap

Secondary technical functions:
- control of concentrated runoff: impede / retard
- reduction of slope angle
- reduction of slope length

Environment

Natural Environment

Average annual rainfall (mm)
> 4000
3000-4000
2000-3000
1500-2000
1000-1500
750-1000
500-750
250-500
< 250

Altitude (m a.s.l.)
> 4000
3000-4000
2500-3000
2000-2500
1500-2000
1000-1500
500-1000
100-500
<100

Landform
plateau / plains
ridges
mountain slopes
hill slopes
footslopes
valley floors

Slope (%)
flat
gentle
moderate
rolling
hilly
steep
very steep

Soil depth (cm)
0-20
20-50
50-80
80-120
>120

Growing season(s): 120 days (September-January), 90 days (March - June)
Soil texture: coarse / light (sandy)
Topsoil organic matter: low (<1%)
Soil drainage/infiltration: good
Soil water storage capacity: low
Ground water table: > 50 m
Availability of surface water: poor / none
Water quality: poor drinking water
Biodiversity: low

Tolerant of climatic extremes: temperature increase, seasonal rainfall decrease, droughts / dry spells
Sensitive to climatic extremes: heavy rainfall events (intensities and amount), floods, land slides

Human Environment

Cropland per household (ha)
<0.5
0.5-1
1-2
2.5-5
5-15
15-50
50-100
100-500
500-1000
1,000-10,000
>10,000

Land user: Individual / household, Small scale
land users, men and women

Population density: 50-100 persons/km2
Annual population growth: 2% - 3%
Land ownership: individual, titled
Land use rights: individual
Water use rights: open access (unorganised)
Relative level of wealth: poor, which represents 75% of the land users; 60% of the total area is owned by poor land users

Importance of off-farm income: less than 10% of all income:
Access to service and infrastructure: low:
employment (eg off-farm), market, energy,
drinking water and sanitation, financial services;
moderate: education, technical assistance, roads & transport; high: health
Market orientation: subsistence (self-supply)
The farmers are careful to isolate the topsoil, then they re-work the subsoil to create the required reverse-slope bench, after which the topsoil is spread over the surface. The riser is planted with short runner grass for stabilization, all within the same period. (Kagabo Desire and Ngenzi Guy)

### Implementation activities, inputs and costs

#### Establishment activities
- Cuttings of grasses
- Transport of grass cuttings
- Planting of grass cuttings
- Land surveying (slope determination, soil structure and texture analysis)
- Construction of bunds (risers) with soil from upper and lower sides
- Level terraces bed (surface soil moved from upper to lower part of terraces)
- Cutting subsurface soil, leveling and refilling surface soil
- Make lips on edges of terraces
- Compact risers
- Plant grasses including agro-forestry trees.
- Input/ application of farmyard manure and liming

#### Establishment inputs and costs per ha

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Costs (US$)</th>
<th>% met by land user</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>525.43</td>
<td>10%</td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
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<tr>
<td>- tools</td>
<td>212.00</td>
<td>1%</td>
</tr>
<tr>
<td>Agricultural</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- seedlings</td>
<td>16.00</td>
<td>100%</td>
</tr>
<tr>
<td>- Lime</td>
<td>200.00</td>
<td>0%</td>
</tr>
<tr>
<td>- Mineral fertilizers</td>
<td>235.00</td>
<td>0%</td>
</tr>
<tr>
<td>- Farmyard Manure</td>
<td>468.00</td>
<td>0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1656.43</td>
<td>4.27%</td>
</tr>
</tbody>
</table>

#### Maintenance/recurrent activities
- Weeding
- Manure application
- Grass streaming
- Cleaning of channels and drains
- Regular repair of destroyed risers

#### Maintenance/recurrent inputs and costs per ha per year

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Costs (US$)</th>
<th>% met by land user</th>
</tr>
</thead>
<tbody>
<tr>
<td>Labour</td>
<td>6.66</td>
<td>100.00%</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6.66</td>
<td>100.00%</td>
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### Remarks:
Factors that affect the cost are labor, soil structure and slope.
The cost is calculated using the rate of US dollars at present time and were estimated according to the cost of construction of one radical terrace. At present the labor is 1.6$ per day. This was calculated on 25/07/2011.

### Assessment
### Impacts of the Technology

<table>
<thead>
<tr>
<th>Production and socio-economic benefits</th>
<th>Production and socio-economic disadvantages</th>
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</thead>
<tbody>
<tr>
<td>+++++ increased crop yield</td>
<td>+++++ Disturbs the fertile top soil</td>
</tr>
<tr>
<td>+++++ increased fodder production</td>
<td>+++++ Require high quantity of FYM and mineral fertilizers</td>
</tr>
<tr>
<td></td>
<td>+ +++ Reduce crop area</td>
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<table>
<thead>
<tr>
<th>Socio-cultural benefits</th>
<th>Socio-cultural disadvantages</th>
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<tbody>
<tr>
<td>+++++ improved conservation / erosion knowledge</td>
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</table>

<table>
<thead>
<tr>
<th>Ecological benefits</th>
<th>Ecological disadvantages</th>
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<tbody>
<tr>
<td>+++++ reduced surface runoff</td>
<td>+++++ The biodiversity is reduced</td>
</tr>
<tr>
<td>+++++ reduced soil loss</td>
<td></td>
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<tr>
<td>+++++ reduced emission of carbon and greenhouse gases</td>
<td></td>
</tr>
<tr>
<td>+++++ increased water quantity</td>
<td></td>
</tr>
<tr>
<td>+++++ increased soil moisture</td>
<td></td>
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<tr>
<td>+++++ reduced hazard towards adverse events</td>
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<table>
<thead>
<tr>
<th>Off-site benefits</th>
<th>Off-site disadvantages</th>
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<tbody>
<tr>
<td>+++++ reduced downstream flooding</td>
<td></td>
</tr>
<tr>
<td>+++++ reduced downstream siltation</td>
<td></td>
</tr>
<tr>
<td>+++++ reduced damage on neighbours fields</td>
<td></td>
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<tr>
<td>+++++ reduced damage on public / private infrastructure</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Contribution to human well-being / livelihoods</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>+++++ The technology is newly established and the soil need enough farmyard manure and inputs to re-stabilize and regain its fertility.</td>
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</tbody>
</table>

### Benefits /costs according to land user

<table>
<thead>
<tr>
<th>Benefits compared with costs</th>
<th>short-term:</th>
<th>long-term:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishment</td>
<td>negative</td>
<td>very positive</td>
</tr>
<tr>
<td>Maintenance / recurrent</td>
<td>very negative</td>
<td>neutral / balanced</td>
</tr>
</tbody>
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### Acceptance / adoption:

70% of land user families (140 families; 100% of area) have implemented the technology with external material support. 5% of land user families (10 families; 10% of area) have implemented the technology voluntary. There is little trend towards (growing) spontaneous adoption of the technology. The real advantages of the technology are observed after 5 to 6 years with good maintenance of structures.

### Concluding statements

<table>
<thead>
<tr>
<th>Strengths and how to sustain/improve</th>
<th>Weaknesses and how to overcome</th>
</tr>
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<tbody>
<tr>
<td>It controls soil erosion → There is a need to plant grasses or trees on risers to stabilize terraces</td>
<td>The establishment of radical terraces is expensive → The construction of radical terraces should be subsided by the government.</td>
</tr>
<tr>
<td>It increases soil water holding capacity → Organic manure should be added to the terrace to effectively increase the soil water holding capacity.</td>
<td>The initial soil structure is disturbed (lost of soil organic matter) → Heavy investments are needed to replenish the soil fertility, especially by adding organic manure.</td>
</tr>
<tr>
<td>It increases fodder availability as new niches for fodder production are created. → High value nutritive fodder should be planted (napier grass, calliandra, tripsucum, etc.) on risers</td>
<td>The establishment of radical terraces decreases cropped land. → Grow high value crops and use adequate quantity of inputs.</td>
</tr>
<tr>
<td>It increases crop productivity → Terraces should be well maintained by providing more inputs and regular maintenance of bench structures</td>
<td>With poor maintenance or poor design of radical terraces, landslides may occur. → To be much more rigorous in the design and implementation/development of terraces by making sure that professionals are involved in the whole process of establishing terraces.</td>
</tr>
<tr>
<td>It reduces soil runoff → Good maintenance of structures</td>
<td>It reduces the cropped land → Farmers should be supported in accessing high value crops and inputs to maximize crop yield.</td>
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