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FOREWORD

The Government of Rwanda has made significant progress towards mainstreaming environmental sustainability issues into the development process. As part of the journey towards realising the Vision 2020, environmental sustainability has been given priority both as a specific sector as well as cross-cutting issue in the national medium term strategies like the Economic Development and Poverty Reduction Strategy (EDPRS I& II), as well as other national, sectoral and sub national planning processes.

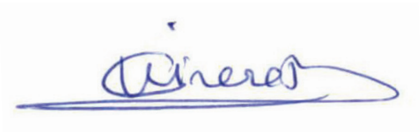
The Government of Rwanda through the Rwanda Environment Management Authority (REMA) with support of the UNDP-UNEP Poverty and Environment Initiative (PEI) programme has been engaged in the generation of knowledge and skills that support practices for integrated food, water and energy self-sufficiency for sustainable living among the rural poor and vulnerable groups. Pilot Green villages under the REMA / PEI programme have successfully demonstrated energy and water self-sufficiency through the generation of biogas for cooking and lighting from consolidated domestic human and livestock waste, and rainwater harvesting for domestic use and small-scale, sanitation and household level irrigation for food production respectively. At a larger scale these practices have the potential to ensure sustained food security, to reduce dependency on firewood fuel and the associated greenhouse gas emissions and reduced respiratory diseases from indoor poor air quality, improved hygiene and sanitation due to clean water, to remove the water-fetching burden and its negative gender impacts and overall poverty reduction and improvement of wellbeing.

The success of these pilot villages has generated strong interest from the Government and development partners to up-scale the Green Village approach into the '*Imidugudu'* resettlement national roll-out programme. Rwanda's national development implementation framework as articulated in the second phase of the Economic Development and Poverty Reduction Strategy (EDPRS II) includes the national roll-out for integrated development planning of rural settlements among the priority interventions for pursuing a Green Economy transformative approach.

This toolkit was designed to provide guidelines for Smart Green Village

implementation and support the users to develop and implement their own similar initiatives in the scale-up process of Smart Green Villages.

We hope this toolkit will inspire more similar sustainable practices.



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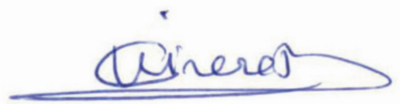
REMA

ACKNOWLEDGEMENT

I take this opportunity to thank all Rwandan institutions particularly Rwanda Energy Group Ltd (REG), Rwanda Housing Authority and those that agreed to release their valuable staff to participate in the review, correction and validation of the toolkit to the successful completion of this Toolkit developed by REMA through Imanzi consultantancy under the supervision of the REMA Team.

I thank all individuals from various institutions namely Mr KABENGA Innocent, Strategic Advisor - Ministry of Natural Resources (MINIRENA), Mr. HIGANIRO Theoneste, Senior Energy Engineer - MININFRA, NDAHIRO Logan, SPIU Program Manager – MINALOC and KALEMA Gordon, Cyber security Engineer – MYICT and Rwanda Energy Group Ltd (REG), REG team and Mr. TUYISENGE Philbert, Planning Engineer; Mr. MUGABO Emmanuel, Community Communication and Mobilization Expert – Rwanda Housing Authority (RHA) and the whole team of UNDP-UNEP PEI programme for their support and guidance on the development of this toolkit.

Finally, I would like to enlighten that this Toolkit aims at being a “living document” that can be replicated by users for the development and management of Green Smart Villages.



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ACRONYMS AND ABBREVIATIONS

EDPRS	Economic Development and Poverty Reduction Strategy
EWSA	Energy and Water Sanitation Authority
MINALOC	Ministry of Local Government
MINEDUC	Ministry of Education
MININFRA	Ministry of Infrastructure
MINIRENA	Ministry of Natural Resources
MYICT	Ministry of Youth and ICT
PEI	Poverty and Environment Initiative
REG	Rwanda Energy Group
REMA	Rwandan Environmental Management Authority
RHA	Rwanda Housing Authority
SMART	Specific, measurable, achievable, realistic and time framed
SPIU	Single Project Implementation Unit
UNDP	United Nations for Development Programme
UNEP	United Nations Environment Programme
VUP	Vision 2010 Umurenge Programme

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INTRODUCTION

1 INTRODUCTION

1.1. Background

The Rwanda Vision 2020 recognizes the social, economic and environmental deficits that Rwanda faces and, as such, emphasizes development options that demonstrate how pro-poor sustainable use of natural resources, including prevention or mitigation of environmental degradation can help achieve development goals.

The successive medium-term strategies (EDPRS 1 & EDPRS 2) and recent sector policies and strategies of all 14 EDPRS sectors have since included environmentally sustainable options among policy priorities.

The main challenge, however, remains in translating policy intentions into tangible actions and results in the form of livelihoods change, equitable economic growth and social transformation.

Practical demonstration of how to achieve pro-poor environmentally sustainable development at the community level was considered important to translate policy intentions into local tangible results, as farmers and other community level groups trust what they can see, and sceptical decision makers can be convinced to prioritise resource allocation to such interventions.

The Government of Rwanda through its key Ministries[1] and through Rwanda Environment Management Authority (REMA) under the UNDP-UNEP Poverty and Environment Initiative (PEI) programme has been engaged in the generation of knowledge and skills that support practices for integrated food, water and energy self-sufficiency for sustainable living among the rural poor and

[1] *MINALOC, MINAGRI, MINIRENA, MININFRA, MINECOFIN, MIDIMAR, MINISANTE, MYICT*

vulnerable.

The PEI programme has facilitated the piloting of "Green" villages within the integrated implementation of mutually re-enforcing policies such as land regularization, planned rural resettlement of Imidugudu[2], land consolidation, crop intensification and livestock acquisition and management.

Pilot Green villages, such as Rubaya and Muyebe Green Villages, in Gicumbi and Muhanga Districts, respectively, have successfully demonstrated energy and water self-sufficiency through the generation of biogas for cooking and lighting from consolidated domestic human and livestock waste, and rainwater harvesting for domestic use and small-scale and household level irrigation for food production, respectively.

This success has generated strong interest from the Government and development partners to up-scale the Green Village approach to the '*Imidugudu'* resettlement national roll-out programme. It was therefore deemed necessary to develop a guiding toolkit for the up-scaling of "Smart" Green Villages. This toolkit can be used by local government authorities namely the District authorities and other key development stakeholders.

The assignment was commissioned by Rwanda Environment Management Authority (REMA).

1.2. Green Village Concept

A Green Village is a process for attaining sustainable development where the local residents can live in a pleasant environment. In other words, by Green village we understand a village which can be developed economically by using natural resources in a sustainable manner, without affecting the natural environment.

[2] *Umudugudu (or Imidugudu in plural): Rural settlements, or "villages", in Kinyarwanda.*

The added term "Smart" to Green Village, refers to the incorporation of appropriate Information Communication Technology (ICT) capabilities for the Green Villages.

1.3. Some Best Practices of Smart Green Villages in Rwanda

1.3.1. Rubaya green village

- **Introduction**

Rubaya Green Village is located in Kabeza village, Kageyo cell, Rubaya sector, Gicumbi District in the North of Rwanda.

Rubaya Green Village was designed by REMA in collaboration with the Gicumbi District authorities, with support from UNEP/UNDP under PEI phase II[3]. The main aim was to practically demonstrate how poverty reduction and economic transformation can be achieved by integrating environmentally sustainable principles, approaches and actions into development activities.

Rubaya sector was one of the 30 poorest sectors identified under the Vision 2020 Umurege Programme (VUP)[4]. According to REMA, the development activities identified under VUP included those that address environment and natural resources management (water harvesting, terracing to control soil erosion, tree planting and agro-forestry, and other sustainable land management practices), while at the same time addressing social and economic challenges identified under EDPRS 1 (i.e. providing jobs to resource poor and under-skilled rural people, rural infrastructure, better housing for poor people, organised rural settlements).

---

[3] *The Poverty and Environment Initiative (PEI) is an initiative of the United Nations Development Program (UNDP) and United Nations Environment Program (UNEP).*
[4] *VUP is a national program under EDPRS1 intended to fast-track poverty reduction and equitable development by identifying and prioritizing resource allocation to one poorest sector in each of the 30 Districts.*

As a pilot integrated environmentally sustainable development intervention, the Rubaya demonstration project was expected to provide an integrated development model that the VUP and other similar national programs could adopt. It had a number of inter-linked components, emphasising efficient, effective, equitable and sustainable use of natural resources using technologies that optimise social, economic and environmental benefits. These include provision of water reservoirs to control run-off and ensure that it is productively utilized, control of soil erosion to reduce soil fertility loss and maintain or improve agricultural productivity and retain much of the water through terracing.

- **Key activities and results of the Project**

The Rubaya Green Village planned to directly benefit 100 households but 43 households actually benefited. According to REMA, the main reason for the reduced number of targeted households was inadequate funding. The beneficiaries were selected among the poorest households and individuals, and their poverty status was set based on the Ubudehe ranking[5]. The following key activities were undertaken during the 5-year period (2008-2013): Construction of houses, water harvesting systems, toilets, cowsheds, and installation of biogas digesters were installed by the time His Excellency the President of Republic Paul Kagame inaugurated the village in June, 2011. The primary school was constructed in 2013.

In more detail, this consisted of:

- Construction of 43 iron-roofed houses each covering a usable space of 100 square metres, with 2 bedrooms, a Kitchen and bathroom, and water collection gutters;

[5] The word Ubudehe refers to the long-standing Rwandan practice and culture of collective action and mutual support to solve problems within a community. Today, the concept has been translated into a home grown development programme whereby citizens are placed into different categories. These categories inform the level of support families receive through government social protection programme

Figure 1-1: Houses in the Village

- Construction of roof-top water harvesting, treatment and supply facilities for domestic water use;
- Construction of 15 runoff water collection and storage reservoirs for irrigation;
- Construction of water-borne, ventilation-improved pit (VIP) latrines for 43 households;
- Construction of 7 biogas digesters, 2 of which have the capacity of 100m^3 each, while 5 others have a capacity of 50 m^3 each, totalling to

450 m^3; and a waste collecting facility (collection and storage of manure);

- Provision of 86 improved breed heifers to each of the 43 beneficiary households and 43 neighbouring households;
- Construction of communal cowsheds;
- Sensitisation, awareness raising and training of community leaders and beneficiaries, to effectively manage, own and sustain the project benefits, through on-site sessions, formal meetings and study visits.

FIGURE 1-2: COWSHEDS

The primary beneficiaries were 43 poor households comprising 200 persons mostly from within Nyamiyaga cell, Rubaya sector, although there were some from outside Rubaya sector. According to REMA (2014), the female-headed households constituted 30.2% (13 households) while 69.8% (30 households) were male-headed. The smallest household is composed of 2 members while the largest has 9 members. The average household size is 4.82 persons. In terms of age, 13.2% of beneficiaries are young (between 16-24 years including a teenage student, a child survivor of the 1994 genocide), 31.6% middle aged (35-44 years) while 21% are over 44 years. At the time of fieldwork, the youngest beneficiary was 18 years while the oldest was 63 years.

1.3.2. Muyebe green village

- **Introduction**

Muyebe village is located in Southern province, Muhanga district, Rongi sector, Ruhango cell. Muyebe village was re-constructed in 2013 by REMA to help different families from Gishwati, Tanzania and others from high risk zones. This village has 2 sites (Muyebe 1 and Muyebe 2). Muyebe 1 is finished and has 105 families. Each family has a 3 rooms and a living room house, an outside kitchen and bath room. The toilet facility with 4 doors is shared with 4 families. To make this village green, REMA rehabilitated existing houses in the village, constructed new toilets, rainwater harvesting systems, cowsheds and distributed cows to households to support their daily lives for environment management.

In more detail, this consisted of:

- **Rain Water Harvesting:**

REMA provided 10 underground tanks, each with a capacity of 100 m^3. All the tanks were connected to the roofs of the houses with a filter composed of charcoal and sand. However, this water from the tank is not clean; the users must boil it to get clean water. Therefore, up to now, the rain water is used to obtain biogas, feed cows and washing. For drinking, the villagers go to fetch water from another source of water in BUSAGA natural forest.

The village beneficiaries grouped themselves in 'UMUCYO' cooperative in which they contribute 3,000 Frw that will help them to maintain these infrastructures. One family is allowed to use 10 jerry cans of 20 litres each per day but in special circumstances where much water is needed like wedding ceremonies or construction works, they sell one jerry can 10 Frw to cooperative members and 20 Frw to non-members.

One of the beneficiaries was trained in maintenance for daily follow up.

- **Biogas production:**

REMA gave a cow to each family in the village and to 105 neighbouring families. These cows share 26 public cowsheds, where 4 families share one cowshed and the same applies to village neighbours. The cow and human waste is used for biogas production which is not only a source of energy, but also stops the waste contaminating the environment. Those 4 families who share a public toilet and the cowshed obtain gas to use in their daily food preparation. They use wastes from the toilet and farm and harvested rain water to get the gas for cooking different kinds of food such as dry beans in 30 minutes and other daily food in 10 minutes. At an agreed upon time, one of them leads the group members in collecting all the wastes from the farm and puts them into the biogas digester. At the time for cooking, he/she will open the valves for the families to get gas and start cooking. He/she opens and closes the valves 3 times a day following this schedule: For breakfast preparation - 5:00 a.m. to 7:00 a.m. ; for lunch preparation - 12:00 to 2:00 p.m. and from 5:00 p.m. to 9:00 p.m for supper preparation.

- **Agriculture resources:**

Apart from these houses and other things provided to these families, they were also given land from Government to cultivate because some moved far from where they used to live to settle in this village. They were given the land for free. They are allowed to keep the land they left and thus earn additional income.

- **Socio-Economic Infrastructure:**

There is a primary school, but there are no nursery or secondary schools, no health centre and no market. While not yet built, they are provided for in the master plan.

1.4. Benefits for the Beneficiaries

The set of technologies adopted in Green Villages of Rubaya and Muyebe, ranging from rainwater harvesting and biogas systems to terracing and tree planting, has improved the quality of life and enhanced environmental sustainability.

As a result of introducing rainwater harvesting systems, use of biogas residue as fertilizer, tree planting and terracing, food security for the community has increased and excess production is being sold to the market.

In Muyebe and Rubaya villages, terracing has helped to reduce landslides on the slopes which used to cause damage to property and in extreme cases loss of lives.

From the sale of milk and fertilizer, the cooperative has an annual income of $26,000 which supports the welfare of the families in Rubaya village.

The biogas generated through the system is distributed to households for cooking. This has reduced the dependency on firewood and thus decreased the deforestation rate. An estimated 14 ha of forest has been saved. Owing to the use of biogas plants, the community has a clean, nontoxic fuel source thereby reducing health issues related to the inhalation of smoke from firewood.

Women and children used to walk about five kilometres down the hill to fetch water and spent significant amounts of time collecting firewood. Having water and biogas for cooking closer to their families has saved significant time, and women and children can now spend their time on more productive activities including school work.

The Rubaya Village Demonstration Project initiative alone has about 200 beneficiaries living in that village and 62 % out of them are women.

1.5. Intended users of the Manual

The list of intended users of the Toolkit Manual includes the following (not limited to):

- National Officials (e.g. from MINALOC, RHA, REMA, etc.)
- District officials
- Contractors
- NGOs
- Residents / Individuals in the villages
- others

1.6. Brief outline of the Toolkit

This Toolkit is a primarily reference document. It is intended to highlight steps for up-scaling the 'Smart' Green Village and designing of any new Green Village. This will help users to replicate these Green Villages in other districts of Rwanda or elsewhere.

The purpose of the toolkit is to:

- Provide step-by-step design manuals for the set of technologies used in Green Village, ranging from rainwater harvesting and biogas systems to terracing and tree planting
- Provide step-by-step guidance for creating "Smart" Green Villages through the incorporation of appropriate Information Communication Technology (ICT) capabilities.
- Provide step-by-step guidance to relevant National and District officials as well as the Private stakeholders, including contractors, in the design, development and establishment of Smart Green Villages
- Provide step-by-step guidance to residents of Smart Green Villages on the individual and corporate ownership and management of Smart

Green Villages fixed assets (houses, infrastructure etc.) and consumable assets (water, biogas, etc.).

Structure of the Toolkit

The toolkit is divided in 2 volumes. Volume I includes the design steps of all the components used in developing a Smart Green Village while Volume II includes the training Compendium for different users.

The structure of Volume I is:

1. Section I presents the introduction, the background and the concept of Green villages including the best practices of Green Villages in Rwanda. It also mentions the benefits received by beneficiaries and intended users of the Manual.
2. Section II describes the Green Village Toolkit Components under various segment as given below
   i. Design steps for Sustainable Agriculture Practices
   ii. Design Steps for Access to Water
   iii. Design Steps for Efficient Energy
   iv. Design Steps for Sanitation & Hygiene
   v. Design Steps for Community settlement
   vi. Design Steps for Value Chain Addition
   vii. Design Steps for Village Knowledge hub

   Each section was prepared as a stand-alone document which can be read and used on its own, or be combined with other sections to constitute the full Toolkit. The emphasis is on practical guidance, drawn from the existing Green Villages of Rubaya and Muyebe, proven systems, techniques and tools and illustrated by examples.

3. Section III gives the conclusion on the implementation of the Green Village initiative.

SUSTAINABLE AGRICULTURE PRACTICES TOOLKIT

2 SUSTAINABLE AGRICULTURE TOOLKIT

2.1 Introduction

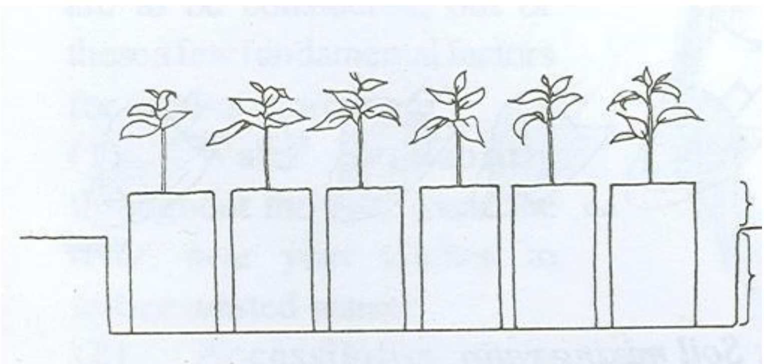
The Sustainable Agriculture Toolkit provides guiding steps for construction of nursery beds, raising seedlings, composting and suitable crops plantation.

2.2 Objective

The main aim of Sustainable Agriculture practice is to provide guidance for the design steps of nursery construction materials, how to raise seedlings, plant and provision of fruits. The preferred species are agro-forestry species that provide multiple functions.

2.3 Key Activities

FIGURE 2-1: ***AN EXAMPLE OF A SUNKEN BED FILLING A RAISED BED MADE FORM BRICKS WITH A MIX OF SOIL AND MANURE***



- Design Steps for Nursery beds and raising seedlings
- Design Steps for Composting
- Design Steps for Radical Terraces
- Monitoring and Evaluation
- Maintenance Plan

2.4 Design Steps for Nursery Beds and Raising Seedlings

STEP 1: Identifying site location

For ease of access to users and maintenance, the factors to be considered in selecting the site for a nursery include:

- Reliable supply of water, ideally being near a river or ponds, or where a water tank or a drum to store water is available
- Accessible all year round, so that customers are able to get seedlings easily, and so that nursery staff can manage plants and transport mature seedlings to planting sites and/or markets
- Good soils and other planting materials such as sand should be easily available
- Protected from strong winds and from livestock,
- Should receive sunlight, and should be on a gentle slope to allow drainage

Types of Nursery Beds to be selected as per location

i. **Sunken beds:** In areas with long dry hot weather, beds are kept slightly below the general ground level. Such beds can be easily irrigated, during dry season. This type of beds are used for raising stock through vegetative propagation like cutting of popular, sissoo, mulberry, willows, and bamboos off sets. Besides these Acacia nilotica, A. benthenwii, Prosopisjuli flora, etc.

ii. **Raised beds:** In wetter areas, nursery beds are raised 10-15cm above the level of the grounds, which can be supported either by bamboos or line of bricks, stones, etc. This prevents their edges from being eroded away during the rainy season or by irrigation or outside water from seeping into the bed. The species which are commonly raised on beds are Deodar, Kail, Spruce, Fir, Robinia, Walnut, Bird cherry, Ash etc.

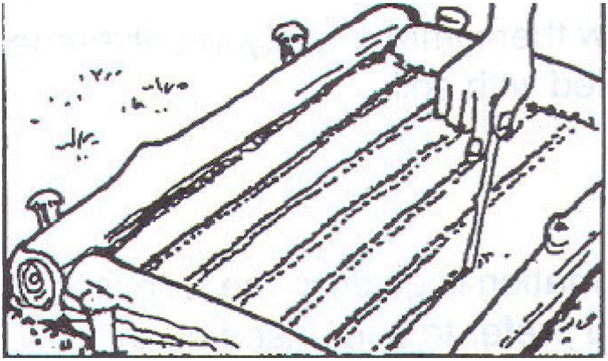


FIGURE 2-2*LEVELING THE SOIL OF A RAISED BED, TO A DEPTH OF ABOUT 2 CM FROM THE TOP*

iii. **Level beds:** Level beds are commonly used for raising seedlings of Tuni, Eucalyptus, Ritha, Terminalia, Siris, Grevillia, etc. These species cannot tolerate standing water; their water requirement is also moderate.

STEP 2: Sizing of Beds

- Size varies from locality to locality. Generally beds are 1-1.2m wide or up to 1.8m wide. This depends on seed beds, either stand out beds for polypots or beds for raising stumps or bare-rooted plants.
- Length of the beds is usually 5-10m.
- Orientation of the beds should be from east to west to provide better shade against the mid-day sun and not more than 50cm. Seed beds and stand-out beds should be provided with frames on which shade can be placed;

whether this is needed for beds for stumps or transplants depending on the species being raised.

- There should be 50-60cm width between beds and the surrounding fence. This means that on terraced land, the terraces should be at least 2m wide.

Factors to be considered on the size of a nursery are:

- The land available on farms may only be small in area, but more space may be available in public land like school yards or church grounds
- Whether you will grow the seedlings in pots or in beds, and whether they will be raised from seeds or from grafts, or from bare rooted cuttings, etc., this will influence the amount of space each plant needs. Additional space is also required for keeping collected soil, sand and manure, and for mixing these materials.
- The numbers of seedlings to be raised for personal use and for sale. When considering the size of the market for seedlings, it is better to start by being conservative in estimating what your market will be.
- The amount of water that is available to maintain seedlings

STEP 3: Preparing the soil

- Dig the Soil in depth of 0.3-0.45m so that stone, roots, etc. lying underneath are all dug out, picked and thrown outside the nursery. If the soil is gravelly, it should be sieved through a fine wire netting to remove gravel.
- Then, soil should be mixed with farmyard manure. At the same time, charcoal dust and ashes are also mixed to correct the acidity of soil and keep away worms.
- If there is a danger of white ant attack, Aldrex 5% dust should be mixed 75kg/ha.
- In the hills, new terraces have to be built with the help of string and pegs, and the drainage network should be planned. The top-soil should be first removed carefully from the surface of the terrace and put in a pile, and after making the terrace, it should be replaced on the terrace surface.

- The surface of the beds should be either flat or preferably given a slight camber. If the soil is heavy, a top dressing of washed river sand is usually given, which prevents the watered beds from becoming pasty and stops splashing during rains. Burning of dry grass and shrubs piled on beds reduces weed growth and is very beneficial for species having minute seeds eg. Adina cordinfolia.

STEP4: Planting the Seeds

- Seeds should be planted at spacing of 15cm between rows. They should be covered lightly and the bed should be mulched with dry grass.
- The bed should be watered thoroughly on the day prior to sowing.
- Mulching a nursery bed soon after sowing seeds is a must.

STEP5: Maintaining the nursery bed

- Mulch the seed bed after sowing until germination.
- Provide enough shade to the crop after germination 1m above the bed. Thin the crops properly, remove weak or diseased seedlings and keep the bed weed-free.

STEP6: Transplanting

FIGURE 2-3NURSERY BED

- Transplant seedlings after 21–30 days. Harden the crop by removing the shade a day before transplanting as this gives the seedling the chance to get used to the direct sun.
- Reduce water at this stage.
- Transplant at recommended spacing per crop early in the morning or late in the evening (from 6:00 a.m. to 10:00 a.m. or 4:00 p.m. to 6:00 p.m.) and
- Plants should receive water as soon as transplanting is done.

2.5 Design Steps for Composting

Objectives of use of compost:

- To improve the soil structure.
- To improve the resistance of the soil against the erosive action of rain and wind.
- To retain water and release it slowly, so that water is available to the plants (water storage capacity) over a longer period.
- To retain nutrients and release them to the plants slowly over a longer period.
- To contain the main nutrients: nitrogen (N), phosphorus (P) and potassium (K), which become available to the plants after decomposition.

STEPS on How to make composting (Rural Household Level)

Step 1: Mark out an area of about 4 feet by 4 feet.

Step 2: Fence the area with four pegs.

Step 3: Get some rotten refuse and spread it on the enclosed layer. The layer may not be more than 5-8 cm in thickness.

Step 4: Spread another layer of well-chopped vegetable material thoroughly mixed to a depth of about 25 cm.

Step 5: Add a thin layer of half rotten animal waste. This layer is called starter because it increases the decomposition of other materials.

Step 6: Sprinkle with some wood ashes.

Step 7: Make successive layers in the order above until the heap is about 1.2m high.

Step 8: Cover the heap with a layer of soil and soak in water.

Step 9: Push a stick into the centre of the heap.

Step 10: Within four days of making the manure, test for fermentation. Pull out the stick to feel the end buries in the soil. If warm and moist it shows bacterial activity. If the end is cold, too wet or too dry, then the compost should be rebuilt.

Step 11: Turn the heap after a month to hasten the rotting process.

Step 12: Repeat the turning once a month.

Step 13: The heap should be ready for application after ten to twelve weeks.

FIGURE 2-4 AGRICULTURE WASTE READY FOR COMPOSTING SAMPLE

2.6 Design Steps for Terracing: Radical Terracing

Types of Radical Terraces

- **Irrigation or level radical terraces:** These are used where crops, such as rice need flood irrigation and impounding water.

- **Upland radical terraces:** These are used mostly for rain-fed crops or crops which only require irrigation during the dry season. They are generally sloped for drainage.

Uses of Radical Terraces

The radical terraces are used to reduce runoff or its velocity and to minimize soil erosion, to conserve soil moisture and fertility, to facilitate modem cropping operations and to promote intensive land use and permanent agriculture on slopes and reduce shifting cultivation.

Radical terraces are particularly suited for these macro conditions:

- Severe erosion hazards;
- Areas with small holdings and a dense population;
- Areas where there are food shortages or high unemployment rates;
- Areas where crops require flood irrigation.

For micro or site conditions, radical terracing is suitable in the following cases:

- Where there are relatively deep soils;
- On slopes not exceeding 25 degrees (47%);
- On sites which are not dissected by gullies and not too stony.

Design Specification

These typical design specifications are common and can be used in Rwanda:

STEP 1 - Length: The length of a terrace is limited by the size and shape of the field, the degree of dissections and the permeability and erodibility of the soil. The longer the terraces, the more efficient they will be. But it should be borne in mind that long terraces cause accelerated runoff and greater erosion hazards. A maximum of 100 m in one draining direction is recommended for typical conditions in a humid tropical climate. The length can be slightly increased in arid and semi-arid regions.

STEP 2 - Width: The width of the bench (flat part) is determined by soil depth, crop requirements, and tools to be used for cultivation, the land owner's preferences and available resources. The wider the bench, the more cut and fill needed and hence the higher the cost. The 22 optimum width for handmade and manual-cultivated terraces range from 2.5 to 5 m; for machine-built and tractor-cultivated terraces, the range is from 3.5 to 8 m.

STEP 3 - Gradients: Horizontal gradients range from 0.5 to 1% depending on the climate and soils. For example, in humid regions and on clay soils, 1% is safe for draining the runoff. In arid or semi-arid regions, the horizontal gradients should be less than 0.5%. The reverse grade for a reverse-sloped terrace is 5% while the outward grade for an outward-sloped terrace is 3%.

STEP 4- Slope limit: if soil depths are adequate, hand-made terraces should be employed on 7 to 25 degree (12%-47%) slopes and machine-built terraces should be employed on 7 to 20 degree (12%-36%) slopes. If the soil depths are not adequate for radical terraces, hillside ditches or other types of rehabilitation measures should be used. Radical terraces are not recommended for slopes below 7 degrees. Broad-base terraces and other simple conservation measures should be used instead.

STEP 5 - Risers and riser slopes: Riser material can be either compacted earth-protected with grass, or rocks. In order to ensure easy maintenance, terrace riser height should not exceed 2 m, after allowing for settling, especially for earth risers. Riser slopes are calculated by the ratio of the horizontal distance to the vertical rise as follows:

- Machine-built with earth material: 1:1
- Hand-made with earth material: 0.75:1
- Hand-made with rocks: 0.5:1

FIGURE 2-5 RADICAL TERRACES PRACTICE IN MUYEBE GREEN VILLAGE

2.7 Maintenance & Management Plan

Nursery Beds and Raising Seedlings

Seedling **protection:** Seedlings are delicate and susceptible to attack by various pests and diseases as well as weather conditions. Such damage can seriously weaken or kill the seedlings. It is important that the damage be dealt with immediately. Damage and disasters in the nursery may be categorized as below.

- **Weather conditions**: Damage caused by the adverse weather conditions. We can either regulate watering or shading to comply with prevailing weather conditions.
- **Human:** Stealing and/or intentional damaging of seedlings by human beings. Fencing and security are such options to overcome this.
- **Livestock and wild animals:** Livestock and wild animals browse or graze on seedlings. Fencing can offset this.

- **Rodents:** Field mice/rates frequently cause serious damage to seedlings in the nursery as well as in the field by eating them. To control these, cleaning the nursery helps to reduce their population.
- **Insects:** Termites are the most common recorded insects in the nursery. They eat the roots and stems of many tree species. Eucalyptus is particularly susceptible to termite attack.

  Termite may be controlled by several methods;
    - Putting a thin layer of ash (2-3 cm thickness) on the bed, where the pots or tubes of seedlings will be placed. However periodic application is required since ash cannot be effective for a long period;
    - Digging out the queen from nearby colonies (termite hills), use of plant extracts and chemicals in severe cases; and
    - If milk packs are used as pots, wash the packs with soap water or solution of insecticide before use, otherwise termites may be attracted.

Composting

- The compost facility should be inspected regularly when the facility is empty. Replace deteriorated wooden materials or hardware.
- Exposed metal components should be inspected for corrosion. Corroded metal should be wire brushed and painted as necessary.
- All fences, railings, and/or warning signs shall be maintained to provide warning and/or prevent unauthorized human or livestock entry.
- To prevent erosion, a good vegetative cover should be established and maintained around the facilities.
- Make necessary repairs. Positive drainage should be maintained around the structure. Inspect and maintain runoff control structures and practices.
- Immediately repair any damage to the structure, earthen areas surrounding the structure, or any appurtenances.

Terracing

- New terraces should be protected at their risers and outlets and should be carefully maintained, especially during the first two years
- After cutting a terrace, its riser should be shaped and planted with grass as soon as possible.
- The outlet for drainage-type terraces is the point where the run-off leaves the terrace and goes into the waterway. Its gradient is usually steep and should be protected by sods of earth. A piece of rock, a brick, or a cement block, is sometimes needed to check the water flow on steeper channels.
- Similar checks on water flow are required for level bench terraces where the water falls from the higher terraces
- Inspect the channel, ridge, and blocks at after harvest.
- Inspect for damage after all heavy rainstorms.
- Remove obstructions such as debris or sediment to maintain capacity.
- Inspect and repair any livestock trails where fields have been pastured.
- Inspect and repair any rodent damage to prevent settling and washouts.

WATER ACCESS TOOLKIT

3 WATER ACCESS TOOLKIT

3.1 Introduction

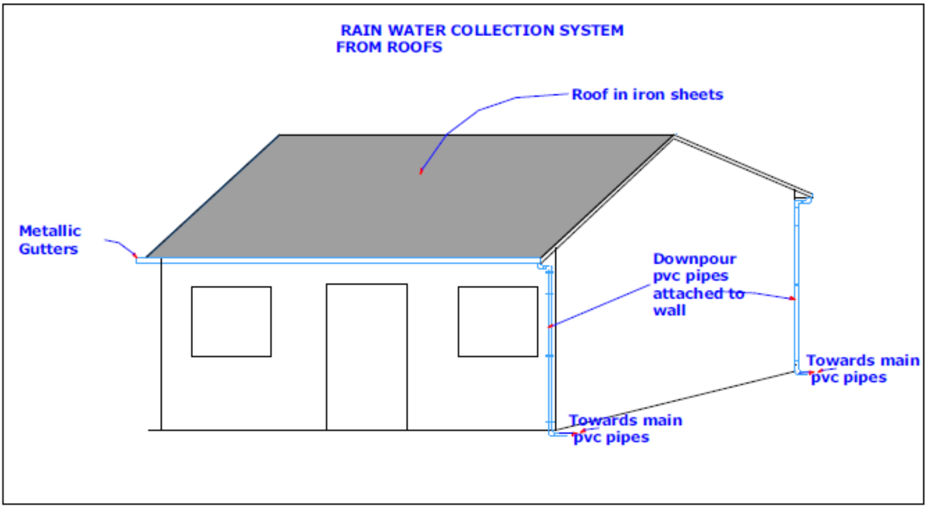
These sections will illustrate the guidelines for water access. In areas where water supply is scarce and source is away from the settlement, rainwater harvesting is the best method commonly used by village residents for both drinking water as well as for agricultural purposes.

Rainwater harvesting consists of a wide range of technologies used to collect, store and provide water with the particular aim of meeting water demand by humans and/or human activities. This toolkit shall highlight the steps in planning, designing and implementing the best practices in rainwater harvesting in developing the Green Village.

3.2 Objective

The aim of rooftop rainwater harvesting (RWH) is to reduce surface runoff and improve the livelihoods of people and families through the multiple uses of rainwater.

FIGURE 3-1 ROOFTOP RAINWATER COLLECTION –TYPICAL DESIGN FOR GREEN VILLAGE



Rainwater harvesting is the gathering or accumulating and storing of rainwater. Rainwater harvesting has been used to provide drinking water, water for livestock or water for irrigation. Rainwater collected from the roofs of houses and local institutions can make an important contribution to meet the water demand for use.

3.3 Key Activities

- Identify the Site
- Design the Steps for Construction of Rainwater Harvesting
- Monitoring & Evaluation
- Maintenance Plan

3.4 Design Steps for Construction of Rainwater Harvesting

Technical Description

A rainwater harvesting system consists of three basic elements:

- Collection area
- Conveyance system, and
- Storage facilities

The collection area in most cases is the roof of a house. The effective roof area and the materials used in constructing the roof influence the efficiency of collection and the water quality.

A conveyance system usually consists of gutters or pipes that deliver rainwater

FIGURE 3-2 ROOFTOP RAINWATER HARVESTING

falling on the rooftop to tanks or other storage vessels. Both drainpipes and roof surfaces should be constructed with chemically inert materials such as wood, plastic, aluminium, or fibreglass in order to avoid adverse effects on water quality.

The water ultimately is stored in a storage tank which should also be constructed with inert materials such as reinforced concrete, fibreglass, or stainless steel. Storage tanks may be constructed as part of the building, or may be built as a separate unit located some distance away from the building. Figure 3 shows a schematic of a rooftop catchment system in the Rubaya Green Village and Muyebe Green Village.

Figure 4 shows the steps in calculating the run off potential to design Rainwater Harvesting.

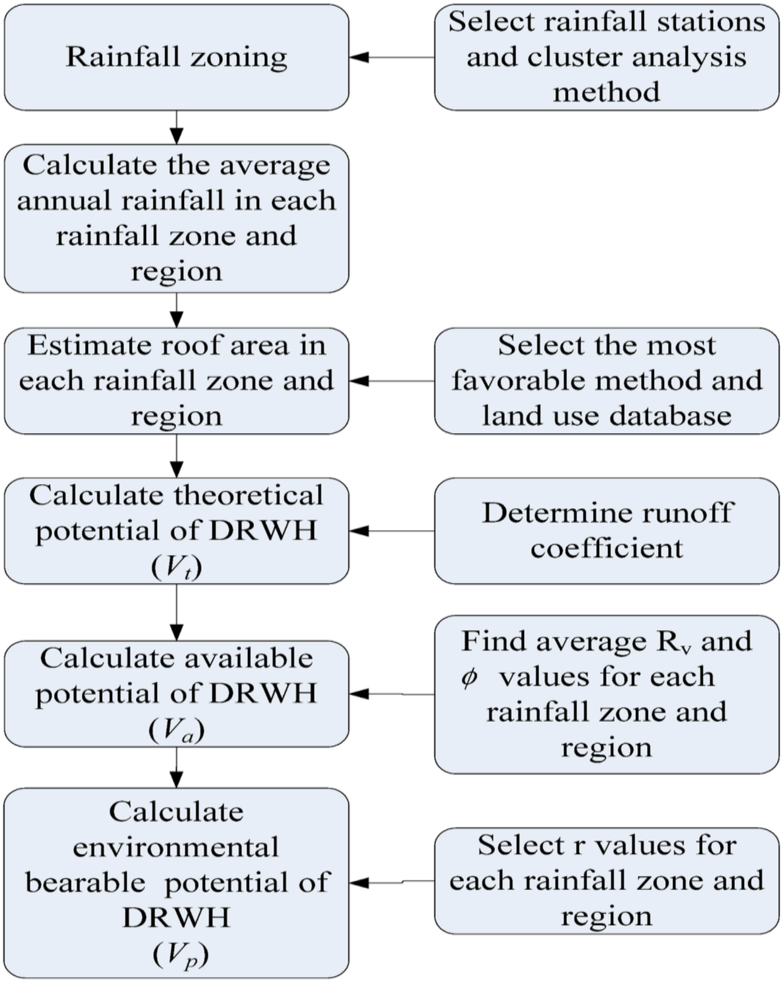


FIGURE 3-3 STEP BY STEP PROCESS FOR DESIGNING DOMESTIC RAINWATER HARVESTING (DRWH) RUN-OFF

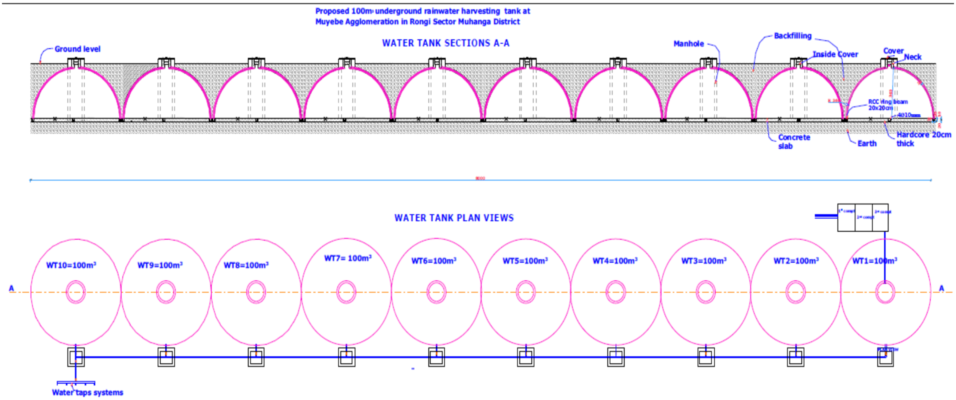


FIGURE 3-4: SCHEMATIC DESIGN OF ROOFTOP CATCHMENT

All rainwater tank designs should include as a minimum requirement:

- A solid secure cover
- A coarse inlet filter
- An overflow pipe
- A manhole, sump, and drain to facilitate cleaning
- An extraction system that does not contaminate the water; e.g., a tap or pump
- A soak away to prevent spilled water from forming puddles near the tank

FIGURE 3-5 COMMUNITY DRINKING WATER TAP IN MUYEBE VILLAGE

3.5 Maintenance& Management Plan

Rainwater harvesting systems require few skills and little supervision to operate. The local beneficiaries will be trained on the maintenance of the rain water harvesting. Major concerns are the prevention of contamination of the tank during construction and while it is being replenished during a rainfall. Contamination of the water supply as a result of contact with certain materials can be avoided by the use of proper materials during construction of the system. The main sources of external contamination are pollution from the air, bird and animal droppings, and insects. Bacterial contamination may be minimized by keeping roof surfaces and drains clean but cannot be completely eliminated. If the water is to be used for drinking purposes, filtration and chlorination or disinfection by other means (e.g., boiling) is necessary. The following maintenance guidelines should be considered in the operation of rainwater harvesting systems:

- A procedure for eliminating the "foul flush" after a long dry spell deserves particular attention. The first part of each rainfall should be diverted from the storage tank since this is most likely to contain undesirable materials which have accumulated on the roof and other surfaces between rainfalls. Generally, water captured during the first 10 minutes of rainfall during an event of average intensity is unfit for drinking purposes. The quantity of water lost by diverting this runoff is usually about 14l/m2 of catchment area.
- The storage tank should be checked and cleaned periodically every six months. All tanks need cleaning; their designs should allow for this. Cleaning procedures consist of thorough scrubbing of the inner walls and floors. Use of a chlorine solution is recommended for cleaning, followed by thorough rinsing.
- Care should be taken to keep rainfall collection surfaces covered, to reduce the likelihood of frogs, lizards, mosquitoes, and other pests using the cistern as a breeding ground. Residents may prefer to take care to prevent such problems rather than have to take corrective actions, such as treating or removing water, at a later time.
- Chlorination of the storage tanks is necessary if the water is to be used for drinking and domestic uses.
- Gutters and downpipes need to be periodically inspected and cleaned carefully. Periodic maintenance must also be carried out on any pumps used to lift water to selected areas in the house. More often than not, maintenance is done only when equipment breaks down.

- Community systems require the creation of a community organization to maintain them effectively. Similarly, households must establish a maintenance routine that will be carried out by family members.
- Residents are advised to boil water before drinking.

Community catchments require additional protections, including:

- Cleaning the paved catchment by removing leaves and other vegetative matter.
- Repairing large cracks in the paved catchment as a result of soil movement, earthquakes, or exposure to the elements.
- Maintaining water quality at a level where health risks are minimized. In many systems, this involves chlorination of the supplies at frequent intervals.

Problems usually encountered in maintaining the system at an efficient level include the lack of availability of chemicals required for appropriate treatment and the lack of adequate funding.

ENERGY EFFICIENCY TOOLKIT

4 ENERGY EFFICIENCY TOOLKIT

4.1 Introduction

This Energy Efficiency toolkit section provides the guidelines for producing biogas for cooking and for solar lamp design and production for energy efficient lighting..

4.2 Biogas

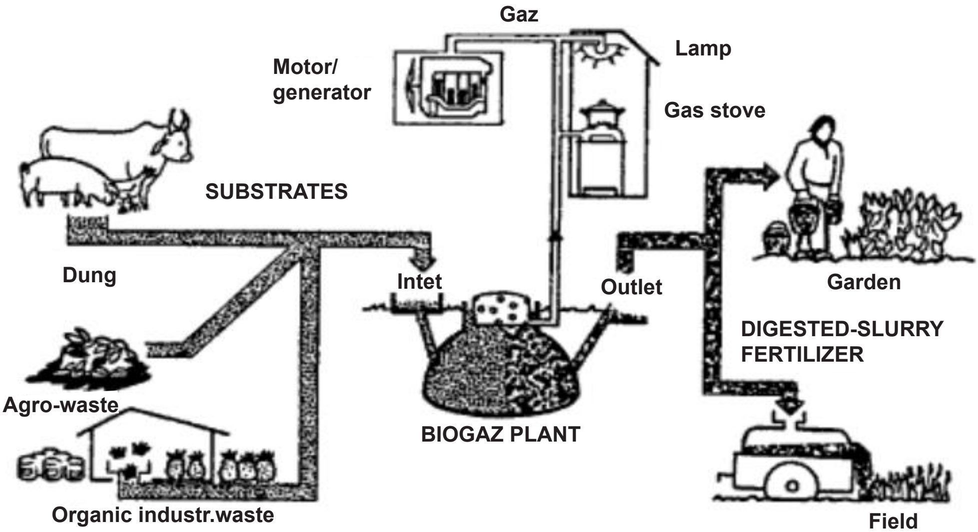
The aim is to support farmers in establishing manure-based biogas cooking systems. These systems provide an efficient energy alternative to firewood and reduce pressure on very limited forest resources.

4.3 Planning & Implementation

Why Biogas?

- Biogas is produced through anaerobic (without oxygen) digestion of manure slurry, resulting in the release of methane gas. The gas can then be captured and safely stored underground to fuel a domestic cooking stove.
- Biogas systems reduce greenhouse gas emissions by preventing methane gas from manure from being released into the atmosphere. They also contribute to the conservation of natural resources by replacing wood-based cooking systems.
- Biogas plants are a preferred alternative to burning dried animal dung as a fuel and can be used for the treatment of human waste.
- Biogas systems are ideal for Rwandan farmers who own dairy cows because they allow them to harvest energy for cooking at a very low cost.

FIGURE 4-1 A TYPICAL BIOGAS SYSTEM - HOW IT WORKS?



4.4 4.4 Design Steps for Construction of Biodigester

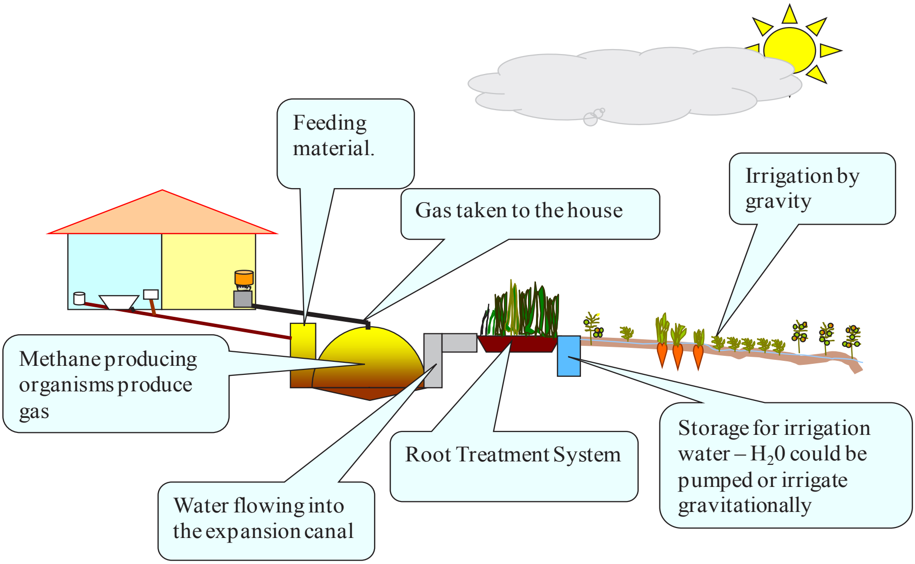
Design Consideration

- Dissemination and implementation of biogas technology has to be organized and planned. Biogas projects are usually quite complex as multiple disciplines like construction, agriculture, economics, sociology besides planning and management are involved.
- It is advisable to create an implementation plan that contains the problem analysis, the objectives, region of dissemination, target groups, the strategy and necessary activities, outputs, required inputs etc
- The size of the biogas plant depends on the quantity, quality & kind of available biomass, average daily feed stock and expected hydraulic retention time of the material in the biogas system.

Technical description

The biogas system installed by EWSA consists of two buried concrete tanks: a digester and an outlet tank (see diagram). Manure slurry is fed through an inlet into the larger tank, the digester, where micro-organisms reduce complex organic matter into methane gas and other organic compounds.

FIGURE 4-2 SCHEMATIC PRESENTATION OF THE PROCESS & USE OF BIODIGESTER



The build-up of methane gas in the digester creates pressure, channelling the gas into a pipe leading to the cook stove. A valve located over ground allows for control of gas flow to the kitchen.

Gas pressure in the digester also flushes the system of spent manure, pushing it through a canal from the outlet tank to an over ground pit.

Note: The detailed technical Design can be obtained from RURA website

Biogas Production

STEP 1:

Manure is collected daily from two cows at a total of 30kg. Manure should not contain bedding straw or dirt. Zero grazing allows easy collection of manure because the cow is confined in a stall.

STEP 2:

Manure is mixed one-to-one with water in a mixer to form slurry. A plug at the bottom of a pipe leading from the mixer to the digester is removed, letting the slurry flow into the digester. The plug is then replaced.

STEP 3:

Once primed and fed daily with new manure, the digester produces methane gas. The more manure in the system, the more gas is produced. During cooking, a valve at the top of the digester tank is turned on to let gas into the kitchen through an underground pipe.

STEP 4:

Another valve in the kitchen is opened to the stove for cooking. The valve controls the size of the hot blue flame produced, and a gauge on a side tube indicates gas pressure in the tank.

STEP 5:

Methane pressure inside the tank pushes the spent manure slurry out of the overflow tank and into a manure pond.

STEP 6:

The manure slurry is removed from the pond and usually added in layers to dry leaves or straw to create a compost pile, which is spread during the next planting season.

4.5 Maintenance & Management Plan

The Local beneficiaries of the Smart Green Villages will be trained on the operation and maintenance of Biogas as highlighted below:

1. Bio-digesters take 50-70 days to begin producing gas regularly. If maintained properly your bio-digester will last for about 7 years.
   - Polyethylene plastic degrades in the sun. If your digester is located in a sunny area constructing a simple roof made of plastic, bamboo, or leaves may increase the life of your digester by several years.
   - A solid plastic cover functions well because it will trap the sun's heat and could improve gas production in your digester.
   - Construct a fence around your digester if there is any chance of damage by animals.
2. Daily maintenance:
   - Charge your bio-digester with two buckets of manure or plant wastes and water mixed to the ratios above.
   - Check the inlet and outlet buckets to ensure that the level of water in the bag is adequate.
   - Check the pressure release valve to ensure that the bottle is filled with water up to the small water hole. If the water in the pressure release valve is bubbling then the digester is functioning properly.
   - Check inlet and outlet buckets to be sure no air is entering.
   - Check for damage to the digester bag. Clean off any mud, stones, or foreign material on the bag.
3. Periodic maintenance:
   - The steel wool inside the PVC "T" assembly must be replaced every 7 months. Check gas lines for cracks and leakage.
   - The discharge from your digester is a clean organic fertilizer. Do not divert this discharge directly into lakes or streams.
4. Giving guidance on the future assessment of how the energy sector strategy will be implemented.

5. Identifying individual goals and objectives that are progressing well according to the plan, and those that are falling short, and suggesting any actions or adjustments that may be needed for the energy sector strategic plan to succeed.
6. A clear evaluation plan will include; who is responsible for reporting, gathering, and evaluating data, data collection measures and timeline for completion of the exercise Solar Lamp for Lighting

4.5.1 Objective

To encourage and promote the use of alternative energy resources such as solar, wind and bio-energy, for meeting the urgent needs of smart villages in Rwanda.

Current situation

Many users rely on kerosene for poor-quality lighting and suffer both the inconvenience and cost of having to travel repeatedly to get mobile phones charged. Ordinary tasks such as homework and chores become difficult or impossible after dark.

4.5.2 Implementation Plan

Begin with implementing the use of solar lamps to replace kerosene lamps in the villages to provide benefits to the villagers such as gainful employment, improvement of health, and reduced of pollution. .

As the alternative for biogas in lighting, REMA thought to provide solar lamps to every family in the demonstration project. These lamps were intended to replace kerosene burning lights that are neither health nor environment friendly. These lamps are now widely used by the students when doing their home work. Before providing these lamps, REMA staff trained every house hold on the best way to use and protect these lamps.

Solar lights need four essential components to function:

1. A **rechargeable battery** to store the power generated by the energy from the sun.
2. A small **photovoltaic cell** or **solar array** that captures sunlight during the day and converts it into electrical energy. The **solar array** is usually built right into the light fixture. Some light designs have separate solar arrays connected by a thin wire allowing the light to be located in a shady area while the **solar array** itself is placed in a bright, sunny location.
3. A **"charge controller"** to ensure the batteries don't get overcharged in bright sunlight as well as to monitor the amount of light in the surrounding area and turn the **LED** (light emitting diode) light on and off.
4. An **LED** (or a series of **LEDs**) which provides the light.

FIGURE 4-3: SOLAR LIGHTS WITH FOUR ESSENTIAL COMPONENTS

4.5.3 Design Specification

Technical specification

- Power supply: lead-acid rechargeable battery (6.5Ah)
- Power output: 5-9 watts
- Light operating time: 4.5 hours
- Radio operating time: 15 hours
- Dimensions: 420 x 135mm
- Weight: 3.3kg
- Time taken to fully charge the batteries: 5 hours

Product function

The solar lantern can be used for indoor or outdoor lighting, or as a power supply for a small electrical appliance (like a radio). As a light, it provides a bright beam (equivalent to a 60 watt filament lamp) spread over a 360 degree area. It can be hung from the ceiling, carried by the handle, or stood on the floor.

A simple lighting circuit is used inside the lantern. The fluorescent lamp is powered by a lead-acid battery and switched on and off using a standard micro-switch. The battery pack is charged by a photovoltaic panel that converts solar energy into electrical energy.

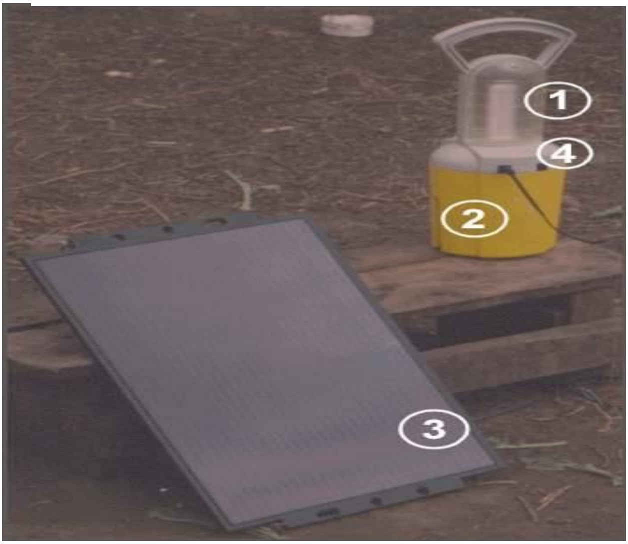
The light comes from a highly-efficient compact fluorescent tube (5-9 watts), which is robust, has a long life and withstands extremes of temperature and humidity.

Materials

The lantern is made from five injection-moulded components - two side panels, a base, a handle and a spacer.

- The body is made from glass-filled polypropylene, which is tough, easy to mould, can withstand extremes of temperature and humidity, and is recyclable.

FIGURE 4-4: EXAMPLE OF SOLAR LANTERN



- The diffuser (which spreads the light through 360) is injection moulded in scratch-resistant PMMA (acrylic). PMMA is ideal for the diffuser because it can be moulded to fine tolerances, has excellent optical properties, and can be recycling.
- A cyclic valve regulated lead-acid accumulator is used for the power supply. This too is completely recyclable.

1. The lantern uses a high efficiency, compact fluorescent tube as its light source.
2. The rechargeable lead acid gel-cell is housed in the base of the lantern.
3. The photovoltaic panel collects light energy from the sun and converts it into electrical current. This energy is stored as charge within the battery.

The output socket can be used to power a small radio.

4.5.4 Maintenance Plan

The Local beneficiaries of the Smart Green Villages will be trained on the operation and maintenance of solar lighting highlighted below:

- The battery can be recharged on a daily basis, as long as there is enough sunlight.
- Families in the Smart Villages can recoup the cost of a lantern within one year. After this, they get free use, as long as the lantern continues to work without any problems.
- The fluorescent tubes used are six times more efficient than standard light-bulbs and last eight times as long.
- A microprocessor is used to control charging and discharging, so extending the battery's life.
- The battery will last for about six years, after which it can be replaced and the old one recycled. The lantern casing can also be used again.
- The casing, which is made from plastics, can be recycled.

SANITATION & HYGIENE TOOLKIT

5 SANITATION & HYGIENE TOOLKIT

5.1 Introduction

The Sanitation and Hygiene Toolkit shall be a guideline tool to increase health and hygiene awareness. The toolkit shall provide design steps of sanitation and waste management technologies that are affordable, inexpensive to maintain, clean and hygienic, use locally available materials, easy to replicate, offer safety and convenience.

5.2 Objective

The Sanitation and Hygiene Toolkit aims at assisting community and users to develop smart hygiene promotion interventions by smart tools that intend to improve hygiene behaviours and environmental conditions.

Specific objectives

- To increase awareness and support the demand created in the community for improved and safe hygienic practices;
- To increase access to skilled service providers for toilet construction and upgrading;
- To ensure standard design and quality in construction, usage and maintenance of toilets;
- To improve health outcomes.

5.3 Key Activities

- Identify the Site
- Planning & Implementation of Sanitation & Hygiene for Green Village
- Design Steps of Sanitation
- Monitoring & Evaluation
- Maintenance Plan

5.4 Planning & Implementation of Sanitation & Hygiene for Green Village

Planning for Sanitation & Hygiene

- To prevent disease: it should keep disease carrying waste and insects away from people and food, both at the site of the toilet and in nearby homes.
- To protect water supplies: it should not pollute drinking water, surface water, or groundwater.
- To protect the environment and increase agricultural productivity: toilets that turn human waste into fertilizer (ecological sanitation) can conserve and protect water, prevent pollution, and return nutrients to the soil.
- To be simple and affordable: it should be easy for people to clean and maintain, and to build for themselves with local materials.
- To be culturally acceptable: it should fit local customs, beliefs, and needs.
- To work for everyone: it should address the health needs of children, women, and men, as well as those who are elderly or disabled.
- Sanitation decisions are community decisions: When decisions about toilets are made by the people who will use them, it is more likely that people's different sanitation needs will be met. Community participation can make the difference between success and failure when a government or outside agency tries to improve sanitation.

- Gender consideration: Women and men have different needs and customs when it comes to using the toilet.

Types of Toilets in Green Village

- Pit Latrines
- Compost Toilet
- Biogas attached Toilets

5.5 Design Steps of Sanitation

Different types of toilets can be used in green village according to the available resources and site characteristics.

5.5.1 Pit Latrines

Pit latrines are the simplest form of dry latrine. They consist of a pit dug in the ground and a cover slab or floor above the hole (see Figure).

Pit latrines must have a cleanable cover slab in order to be considered as improved sanitation systems. The excreta (both faeces and urine) drop through the hole to enter the dry pit. Pit latrines should be constructed on a slight mound so they are higher than the surrounding ground and water at the surface will flow away from the hole. They should also have a lid that can be placed over the hole to reduce problems with flies and odours. They may have a squat pan or a raised footrest to make using the latrine more convenient. The pit is often lined but the bottom remains open, allowing the liquid to drain into the soil and leaving the solids behind.

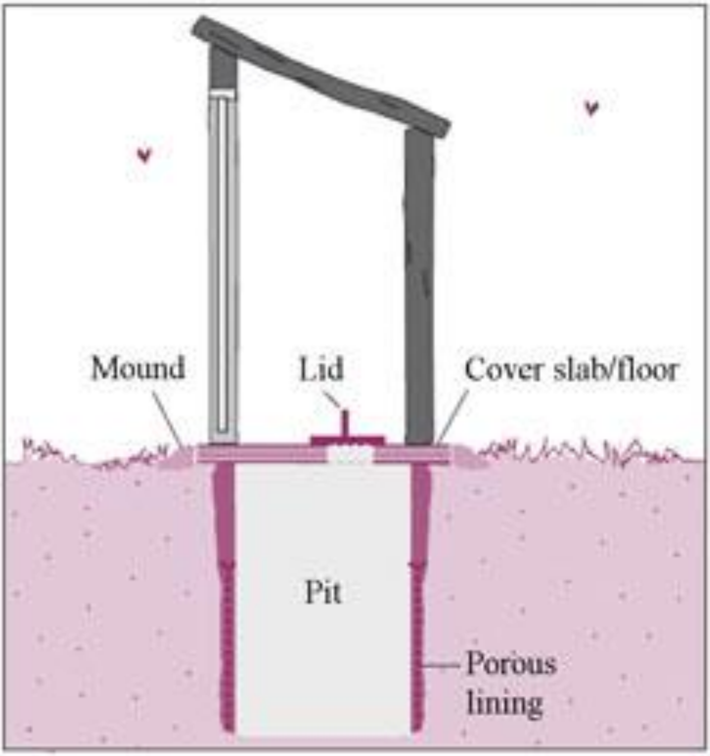


FIGURE 5-1 PIT LATRINE - TYPICAL DESIGN

Sitting, Designing and Constructing Pit Latrine

- The site of a latrine should preferably be in the backyard of the house and away from an alley in the village.
- It should not be nearer than 6 m or farther than 50 m from the house.
- The direction of the wind should be away from the main house.

- If there is a well in the compound, the latrine should be located as far away from it as possible on the downhill side to avoid possible seeping and contamination of groundwater.
- The faecal microorganisms may migrate from the pit through the soil, however, the degree that this happens varies with the type of soil, moisture levels and other environmental factors. It is, therefore, difficult to estimate the necessary distance between a pit and a water source, but 30–50 m is the recommended minimum, with an absolute minimum of 15 m.
- The size of the pit depends on the number of people using it and the design period, i.e. the length of time before it is full. Typically, the pit should be at least 3 m deep for a family of five for a design period of three to five years. The diameter should be at least 1 m; up to 1.2 m diameter will make it easier to dig but if it exceeds 1.5 m there is an increased risk of collapse, especially in sandy soils.
- Need to consider the geology, soil type and topography (the slope of the land)
- The pit must be entirely above the water table at all times of the year. If the water table is near the surface of the ground, the waste in the pit may contaminate the groundwater.
- Lining the pit prevents it from collapsing and provides support to the superstructure. The pit lining materials can be brick, rot-resistant timber, concrete, stones, or mortar plastered on to the soil. If the soil is stable (i.e. no sand or gravel deposits or loose organic materials), the

whole pit needs not be lined. The bottom of the pit should remain unlined to allow the percolation of liquids out of the pit.

- The superstructure should be built using locally available materials. These may include a masonry wall made of cement blocks, bricks, or stone with cement or mud bindings; or a wooden structure covered with timber, bamboo, grass/thatch, sticks, leaves of banana or enset trees, or canvas made of sacks. However, the type of superstructure depends on several factors such as a household's financial capacity, the availability of construction material locally, local customs and traditions, and the availability of skilled artisans.

Maintenance Plan

Pit latrines must be properly maintained to function properly. Advise/train families to keep the squatting or standing surface clean and dry. This will help to prevent pathogen/disease transmission and limit odours.

If the pit was dug to an appropriate size for the number of users, then it may never become full. The liquid will drain into the soil and the solid waste will slowly decompose so the volume remains stable.

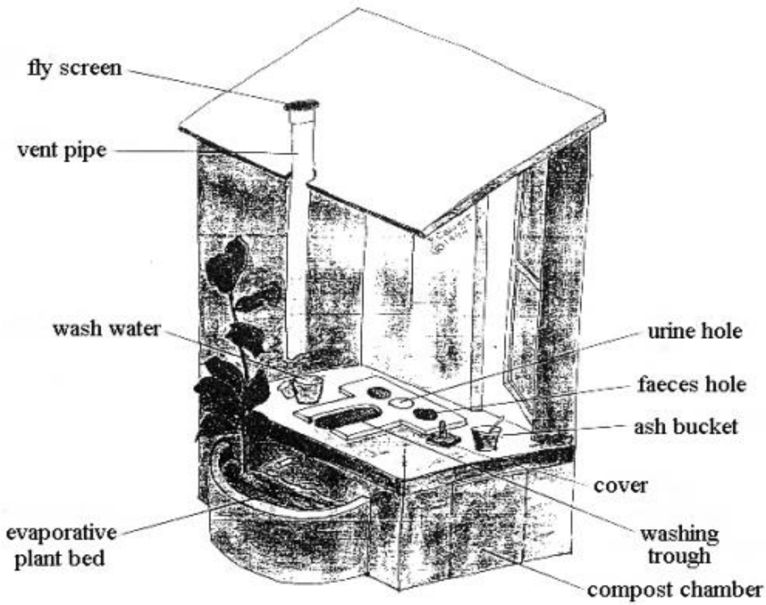
5.5.2 Compost Toilet

The compost toilet is designed to be a highly effective solution to sanitation in high water table and waterlogged areas. However, it can be used as a reliable and low cost water conserving technology in many other areas as well. It can be built beside or as part of a house in rural settings.

Designing and Construction of Compost Toilets

Location: Any toilet would usually be located on the down-wind side of a dwelling and the same applies for compost toilets. However, when built and designed well with good education, the compost toilet does not give any bad odours and can be placed almost anywhere. It should be remembered that vent pipes only function effectively when there is a passage of air over the top of them. Therefore, site selection should take into account this. Access for compost removal should be within the owners plot to prevent disputes later, especially important in very crowded communities.

Construction: The compost toilet comprises a raised slab over two chambers.



Compost Toilet

- The chambers are built on the ground, not in it. In much waterlogged areas, or those prone to flooding, a slightly raised plinth can be made.
- The chambers are plastered with cement internally in order to waterproof them and make compost removal tidier.
- Over each chamber there is a hole in the slab for faeces and a funnel to receive the urine. In the centre of the slab, between the two chambers, is a trough over which the anal cleansing is performed.
- The anal cleansing water trough and urine funnel is inter-connected and flow to an evaporative plant bed outside the latrine.
- In the simplest version, the chamber doors are closed by bricks and mud mortar or appropriate locally available material, both of which can be reused to close it again.
- The chambers are designed to have an accumulation time of about nine months to allow thorough composting of the contents and elimination of pathogens.
- The compost produced is an almost dry, crumbly, black product having a light, pleasant, earthy odour. There is no fly nuisance or any odour problem and the toilets remain clean and pleasant to use.
- The plant bed needs almost no maintenance and the only requirement is to cut back excessive growth which can be chopped up and added to the compost chamber if required.

Operation and maintenance

Before starting to use the latrine, each chamber is half filled with straw, twigs or dry leaves. These provide the necessary additional carbon to the composting process and along with the faeces will compost down to a fraction of their original volume. Occasionally, additional straw may be added through the faeces hole if the contents of the chamber start to become wet or slightly odorous. After each use, a spoonful of dry cooking ashes or lime should be sprinkled down the faeces hole which is then closed using a simple cover. When one chamber is full its defecation hole is sealed and use of the second chamber begins. Once the second chamber is full the first is opened, the compost is removed and the chamber is re-primed with straw. The compost can be put around flowers, plants or trees. The urine and wash water go directly to the plant bed where flowering plants grow. The plant bed does not leak to the ground because it is sealed. Being diluted by the wash water, the urine does not smell and is quickly absorbed by the soil in the plant bed and feeds the plants. The plant bed area depends on local climate and the number of users.

5.5.3 Biogas attached toilet

The biogas attached toilet recycles human excreta, along with other types of waste such as cattle dung, to produce biogas, which can be used for cooking and lighting and slurry that can be used for composting. Almost all of these are fixed dome type plants with capacities of 4, 6, 8 or 10 m3. The ordinary biogas attached toilet can be slightly modified by replacing the pan in the toilet with urine diverting to collect urine separately and send only the faeces along with the flush water and anal cleaning water to the biogas digester.

Design Steps for Construction Process of Biogas Attached Toilet

1. Site selection and layout of toilet
2. In toilet attachment to the plant, it is better to construct pan without siphon or trap as the pan with siphon needs more water to drain the excreta which may result more water inside the digester affecting the hydraulic retention time and total solids in the slurry;
3. The toilet inlet pipe should enter the digester tank no more than 45 degrees from the centreline of the main inlet pipe;
4. Additionally, the pan level of toilet should be at least 15 cm above the overflow level in the outlet walls.

5.6 Maintenance & Management Plan

The local beneficiaries of the Smart Green Villages will be trained on the operation, maintenance and importance of Sanitation and Hygiene highlighted below:

- Routine cleaning of toilet pedestals to ensure good hygiene and proper use. Care should be taken to prevent chemicals from entering into the poop drum as this will ruin the composting process.
- Cleaning inside and outside of the toilet structure.
- Verifying that sufficient cover material is being applied by users.
- Making cover material available to each user.
- Timely removal and storage of filled drums to avoid any human-faecal contact from overfilled drums.
- Proper installation of drums with the help of the guide in the bottom chambers.
- Periodic verification of clear and functioning urine pipes to avoid blockages in the seat’s drain.
- Provision of water and soap for the hand washing system.

- Ensuring that the toilets are accessible to all members of the targeted population.
- Educating first-time users on the basic steps of using a urine-diversion toilet.

COMMUNITY SETTLEMENT AND HOUSING DESIGN TOOLKIT

6 SETTLEMENT AND HOUSING DESIGN TOOLKIT

6.1 Introduction

The Community Settlement Toolkit shall guide the process of group settlement and design steps of planned housing construction in green villages so as to solve the problem of land scarcity and environmental management at the same time.

6.2 Objective

To protect households in scattered settlements and in steep slopes from climate-related disasters like water shortages, strong winds, landslides and erosion.

- Easy access to infrastructure
- Increasing resilience and adaptation to any disaster occurrence
- Having quality and affordable housing
- Strengthening the institutional and regulatory framework at national and local level;
- Resettlement of families living in high risk zones and other poor habitat conditions

The main objective of National human settlement policy in rural areas is the improvement of the existing system of human settlements for sustainable socio-economic development and promotion of grouped settlements in rural areas with environmental considerations.

6.3 Key Activities

- Identify the Site
- Identify the beneficiary population
- Preparation of Zoning Plan
- Development of Layout plan
- Construction and earthmoving
- Monitoring & Evaluation
- Maintenance Plan

6.4 Planning and Implementation of Community Settlement

Site Selection

Settlement committees including the technicians are responsible for selecting the site. Then, the community along with the sector and district councils justify and approve the site selected. Site selection should consider the following as mentioned in the Ministerial decree issued by the Minister for Local Government:

Every cell with over one hundred families or two cells close to each other should choose a site to accommodate at least 100 to 200 houses. It can as well have up to about 500 maximum to attract a small business for entrepreneurs to do some business. Slowly, these settlement villages grow and become trading centres and later they may grow into small towns.

Main Features of Site Selection

- A site should have basic infrastructure in place or should be where infrastructure can be put in place with ease at least cost.
- Should be near the crop farms not more than 3km away.
- Should not be in high risk zones, valleys or near swamps

- Should be on less fertile ground where practical.
- Settlement sites should not be so close to each other except perhaps in hilly places where two adjacent hills can make one settlement. At least each village should be in a distance of 4kms apart.
- IDP model villages layout plan design by MINALOC should be considered while planning for site selection of Green Smart Villages

Case of Rubaya Green Village:

43 poor households were relocated from marginal areas and settled in a modern, accessible site that is relatively disaster free. Access to water and energy, information and improved food security provide resilience to climate effects.

Zoning Plan

Demarcate Land for Settlement and Roads

- Parcel size : 300 – 500 sqm (preferably semi-detached houses , 4 in 1 and 2 in 1 houses)
- Settlement area zone with two adjacent houses adjacent to each other and both facing the road
- Rationalise land use by constructing multiple households in one plot (Example 4 in 1:

Household 1	Household 2
Household 3	Household 4

TABLE 6-1: FOUR HOUSEHOLDS IN ONE PLOT

- Plots and roads network: each parcel is accessible to road
- Demarcation of area reserved for socio-infrastructures: School, health centre, multipurpose hall, commerce, entertainment areas, etc.
- Others areas: Forestry, green area, *umudugudu* extension, etc.
- The road should be planned considering the slopes not exceeding the 40% so as to reduce occurrences of soil erosion

- The size of the road in between the site should have minimum width of 8 m-10 m.
- Roads connecting houses should be at least 6m–8 m in width.
- A well planned village should have major infrastructure like electricity, roads, water, a school nearby, and administrative buildings planted with trees.

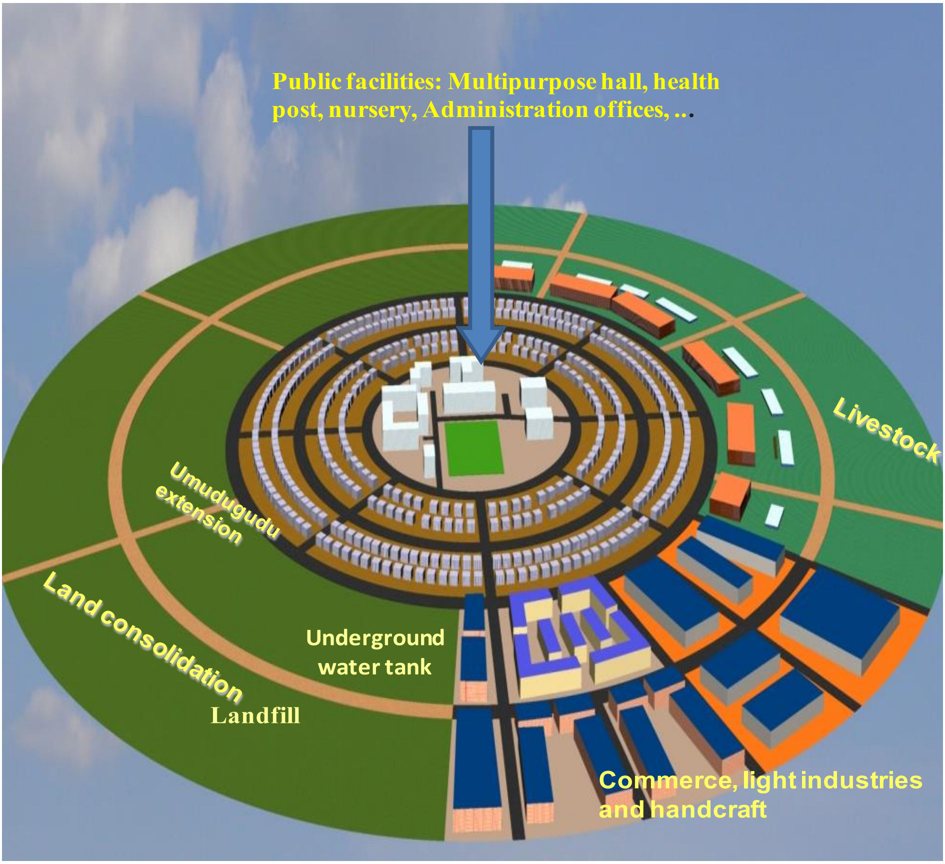


FIGURE 6-2ACCESS ROAD ALONG THE SETTLEMENT

Demarcate Land for agriculture and livestock farming.

- Land for agriculture should be set aside and the land consolidated to boost production and these farms should not be more than 3 km away. Common kraals are encouraged near the settlement for the population to access manure for the crops.
- Large Farms for animals may be far from the settlement in extended grazing farms but the owners can as well be settled in small villages.

Demarcate land for infrastructure facilities:

- Schools -25 000m^2= 2.5 ha;
- Health centre 15 000m^2= 1.5 ha;
- Market place: 40 000m^2= 4 ha.
- It's also very important to reserve space for a common cemetery (Burial ground), public rubbish grounds etc.

- Not every site can have its own infrastructure but close settlements can share.

**Area/ size can vary depending on Land Availability on site*

Demarcate Land for Common grounds

- Land to be demarcated for common uses like open space left and planted on trees, grass, play grounds and dumping places.

Demarcate Space for expansion

- Every site is expected to be left with enough space for expansion future use

6.5 Design Steps of Green Village Housing Construction

Design Consideration

GREEN BUILDING

Green Architecture is a philosophy of building design, material selection, construction technique, and mechanical systems that can reduce immediate and long term environmental impact and improve the aesthetic and utilitarian quality of the habitation. Green architecture can also be cheaper if one considers the cost of energy over the life of the building, as well as potentially improved health and productivity in the structure.

Components to be considered while designing green building in Green Smart Villages:

- Avoid steep slopes where excavation quantities are high and erosion control will be difficult.
- Use site slope to take advantage of gravity flow for water and wastewater systems.

- Design for natural day lighting to reduce electrical consumption.
- Choose local materials (earth blocks, stone) for wall building
- Minimize use of imported materials including paints, metals, and plastics.

Energy Efficient Building

Although located only two degrees south of the Equator, Rwanda's high elevation makes the climate temperate. Buildings in mountainous areas should emphasize solar heating and insulation, but this is less

Figure 6-3 Larger vents design above windows important in mid-elevation areas.

In the eastern savannah where temperatures are higher passive cooling is more important.

Placing larger vents higher on the wall with intake vents in a cool area of the house low on the wall will promote convective currents in the house.

FIGURE 6-4 TRADITIONAL ADOBE HOUSE BEFORE PUTTING ROOFING

Traditional adobe or compressed earth block construction is useful for reducing indoor temperature variations due to its high thermal mass. Instead of insulating the interior space from outdoor high and low temperatures, walls with high mass will slowly gain heat during the day and slowly release this heat during the night.

Building Materials

Materials for Green building must balance durability with sustainability and energy costs, which includes production and transportation. This is especially important in Rwanda, where relatively few natural resources exist and the transportation sector is requires development.

The most common construction materials in Rwanda are soil, concrete, cement block, and brick, although stone is also common in foundations and sometimes used for walls. Soil is common in traditional housing.

Soil blocks can be adobe or compressed earth blocks (CEB's), and CEB's can be made with manual or powered machines. Manually produced CEB's (Makiga) are recommended for low-cost housing, and machine made blocks (Hydraform) are more appropriate for institutional or commercial construction due to higher production and better quality. CEB's should be stabilized with cement or lime to provide higher strength and better durability.

FIGURE 6-5 ADOBE BLOCKS

Plot Sizing

- The plot size should be at least between 400m and 600m depending on availability of land. It not worth locating a settlement site where there is a slope of more than 40%.

Housing Layout

- The accepted houses in rural areas are semi-detached houses, mainly 4 in 1 houses. 2 in 1 houses can be constructed due to the topography of the site.
- The maximum plot size for 4 in 1 houses is 25m x 20 m and 15m x 20m for 2 in 1 houses.
- One dwelling unit will contain 3 bedrooms and 1 living room (salon). The number of rooms and the room size should be increased or decreased due to the household size.
- Dwelling unit will be composed of 1 main house, 1 annex (kitchen, bathroom, toilet,…) and a "Akarima k'igikoni" for vegetables and fruit.
- Water tanks will be provided to all houses
- All houses will be connected to the central underground water tanks
- By implementing 'One Cow per one family programme'', the Biogas system will be introduced.

Housing Detailed Design for Semi Detached Houses

Sizing of the Main house, Kitchen, Store, Bathroom and Toilet

- **Living house:** A rural house of between 5-6 people should at least be of 56 m^2 with two-three bed rooms and a sitting room. It can be increased in size as means avail.
- **Kitchen:** In order to have a sizable room for preparing meals, the size should at least be of 7.2 m^2.

FIGURE 6-7: SEMI-DETACHED HOUSES 2 IN 1 - PROPOSED RESIDENTIAL HOUSES, (RHA, 2015) PLOT SIZE IS 20 M X 20 M

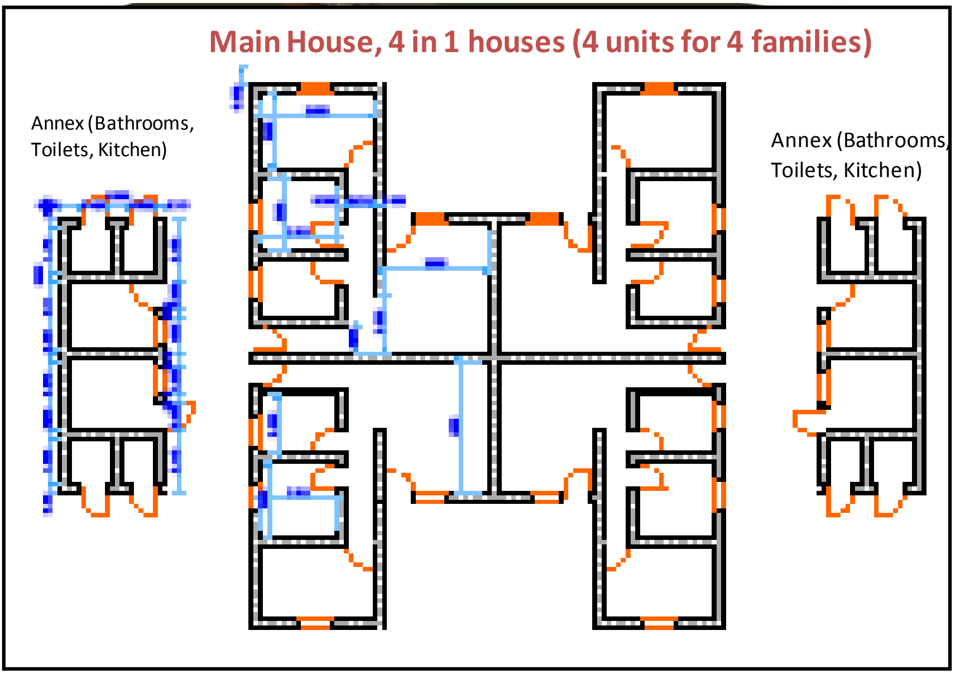


FIGURE 6-6: SEMI-DETACHED HOUSES 4 IN 1 - PROPOSED DESIGN PLOT SIZE IS 25 M X 20 M

- **Store, Bathroom and Toilet:** The store and Bathroom should both be sizable, for purposes of cleanliness; every home should have a toilet with a depth of between 12-20 m where possible.
- The main house should be constructed 6m away from the road. The kitchen, stores, bathrooms and toilet should also be near the living house. The house should have gutters for rain collection and a water tank for storing the water to be used in the home.

Construction material for Semi-detached Houses

- Partitioning wall (internal wall) will be made of earth blocks (Rukarakara) and external walls will be made of concrete blocks, compressed earth blocks (hydraform bricks) or burnt bricks.
- Number of bedrooms will be less than 3 (2 or 1 bedroom)
- Size of bedrooms will be 3 m x 2.5 m each, minimum
- The thickness of the plastered wall will be 25 cm for external walls

    2 options for roofing: the use of tiles or iron sheets depending on the local availability

6.6 Maintenance & Management Plan

The Local beneficiaries of the Smart Green Villages will be trained on the design, construction, operation and maintenance of Green Buildings highlighted below:

- All the local community people will be involved in the design, implementation and management of human settlement programmes and in all implementation phases of the human settlement regrouping operations;
- Local community participation during the construction process;
- Local communities and cooperatives will be trained in appropriate technologies to enable them to participate fully and usefully in the socio-economic development of Green Village Community Settlement;
- Support, marketing and distribution mechanisms of the local building materials will be identified;
- Making plans for maintenance of rural Houses: The housing which need to be implemented for:
    - Periodical repair
    - Maintenance work
    - Implementation time
- Construction of rural settlements must follow all instructions contained in RHA documents;

- A construction specialist (civil engineer at least) must train the local community while constructing the rural houses and further supervise and monitor all construction activities;
- Local masons should be trained on the construction of houses with disaster resilience considerations;
- There must be a close collaboration between Government institutions including REMA, MINIRENA, MINEDUC, MININFRA, MIDIMAR and MINALOC in terms of decision making regarding environment, infrastructures development and disaster risk reduction;
- Periodic monitoring at community level for any cracks in houses or re-building required in the Green Village.

VALUE CHAIN ADDITION TOOLKIT

7 VALUE CHAIN ADDITION TOOLKIT

7.1 Introduction

The Value Chain Addition Toolkit shall help in designing and implementing the Smart Green Villages which are self-dependent in providing the services and employment.

7.2 Objective

The main aim of Value Chain Addition Toolkit is to have a self-reliant economic opportunity at the village level realizing smallholders' capability to establish and sustainably manage a competitive and economically viable local dairy value chain. The Toolkit shall use a value chain approach as a framework to identify the possibilities for upgrading and the determinants of competitiveness in adding value to its local products in which smallholder farmers can participate.

In this toolkit, the dairy value chain, fruit processing with focus on banana and grain Processing in the Green Villages will be discussed and the design steps of processing at each stages and adding value at local level will be explained in step by step.

7.3 Design Steps for Dairy Value Addition

Keys activities/Steps in dairy value chain addition

- Production
- Collection preserving quality
- Freezing/Cooling
- Processing
- Transport/Distribution

- Marketing/ Retailing

Farmers in existing Green Villages produce fresh milk with the help of agricultural inputs and artificial insemination. Surplus milk is then sold to a retailer, a transporter, a chiller/bulker or a processor. A chiller/bulker aggregates fresh milk and chills it, thus delaying spoilage, before re-selling the milk to a retailer or processor. The processor adds value to the milk by extending its shelf life and producing a variety of goods. Often, payments are made to transporters in order to move milk to the next link in the value chain.

Value Chain Addition at Local Level: Milk can be transformed into various milk products to increase its shelf life such as UHT treated milk which shelf life can go up to several months. The following are some of the milk products processing steps which the Smart Green Village can develop at local level by developing a small processing center for the following products:

Fermented milk

Fermented milk is a cultured milk product formed through the transformation of lactose to lactic acid by the use of selected microorganisms with the formation of other metabolic by products which is important in aroma and flavor development. Fermented milk has a pH of less than 4.6 and this can be a means of preservation for the milk product. Lactic acid in the fermented milk has two roles:

- For the development of the characteristic sour taste of fermented milks;
- As a preservative for the product.

Two main fermented milks are:

Curd milk (Ikivuguto)

This is skimmed or whole milk fermented by a mixed starter cultures of Streptococcus cremoris, Streptococcus diacetylactis and Leuconostoc citrovorum. The fermentation process is started by S.cremoris which makes the conditions anaerobic for L.citrovorum, then followed by S.diacetylactis which converts citric acid to acetic acid, acetaldehyde, CO_2 and diacetyl which is an important aroma compound. This culture has advantages in that:

- It is high in aroma compound and low in CO_2 production
- The optimum temperature range is 15 - 25°C i.e. ambient implying that fermentation process can be carried out at ambient temperature without the need for incubators.
- Fermentation stops when the lactic acid concentration is 1%.This means that there is no need to store the product at low temperature to stop fermentation and therefore the product can be stored at ambient condition.

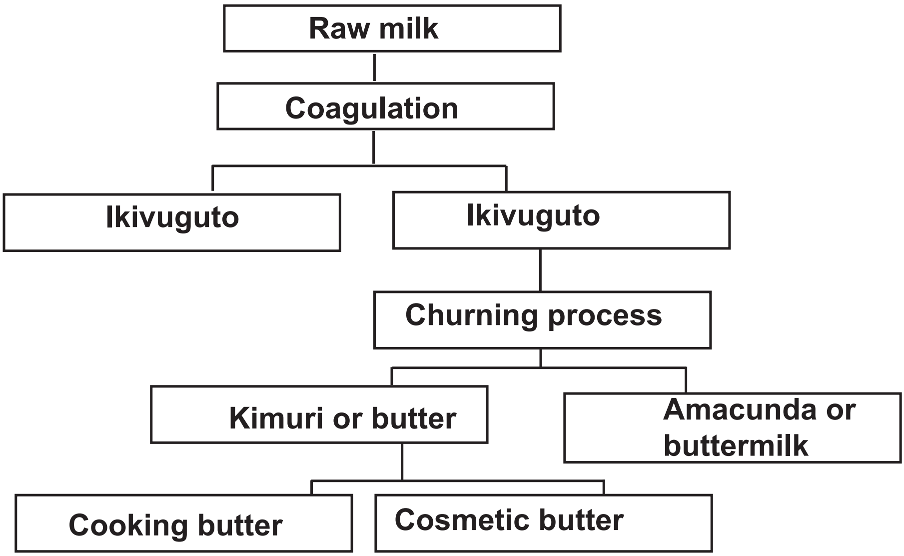


Figure 1. *Diagram showing the processing of kivuguto and its by - products- schéma de préparation du kivuguto et de ses dérivés.*

Manufacturing process

- Milk is pasteurized and cooled at 20 - 25°C and inoculation with 2 - 3% starter culture.
- Then the pasteurized milk is incubated at ambient temperature for 15 - 20 hours. The time depends on aroma development which depends on the activity of the microorganisms.
- Short stirring to a smooth consistency and retail packaging. The keeping quality of curd milk at ambient temperature is in the order of 4 - 5 days but the keeping quality under refrigeration can extend to 2 - 3 weeks.

Yoghurt Manufacturing

The raw materials generally include milk and skimmed milk. In addition, other food materials such as sweeteners, stabilizers, and flavor and fruit preparations are required as components of yoghurt mix. These materials are blended together in proportions to obtain a standardized mix conforming to the particular product to be manufactured.

The yoghurt mix is pasteurized and homogenized then the product is cooled at 40 - 45°C. The mix is inoculated and temperature is maintained throughout the incubation period to achieve the desirable treatable acidity. The incubation period is usually 2 - 3 hours to achieve a TTA of 0.8%. Then the yoghurt mix is taken into cold room to stop further fermentation.

Cheese manufacturing

There are several types of cheese depending on the manufacturing process. Example Cheddar Cheese:

- Milk is pasteurized and cooled to 31°C
- Then 1 – 2.5% of its volume of starter culture is added in order to obtain a growth lactic acid forming bacteria

- After attaining an acidity of 0.2% enough rennet solution is added so as to coagulate milk in about 30 minutes. After the curd has formed it is cut with curd knives to small cubes and allowed to settle for few minutes. It is then stirred gently to keep the cubes floating.
- The cutting of the curd has two purposes:
  - To speed whey expulsion
  - To assist in uniform cook of the curd by increasing the surface area
- The temperature of the curd and whey is then slowly raised at about 1°C in every five minutes to 38°C - 39°C through indirect heating to avoid dilution of whey so that it increases in acidity fast.

Continuous stirring should continue. This is called cooking the curd; its aims are:

- It makes the curd particles more resistant to damages as they shrink in size and become tougher
- There is effective expulsion of whey through shrinkage
- There is development of texture
- There is establishment of moisture control
- Suppresses spoilage organisms

The whey is then drained off a process called dipping. As the whey is drained one half of the curd is pushed to each side of the vat in order to form a trench or ditch a long which the whey escapes. Then the curd is piled up, the piled curd is then cut into strips or slabs. These are moved slightly apart to allow drainage of whey between the slabs. During the pilling of curds they are held at 35 -38°C and turning them every 10 - 15 minutes. The curd is well pilled and become quite plastic. The curd is then milled and spread at the bottom of the vat. Salt is then mixed thoroughly with the curd pieces. The amount of the salt will depend upon the market preference but is usually 2 –2.5% NaCl. The salt added influences flavor, body and moisture. The salting stage halts the acid production and so the pH of the curd does not decrease further after salting. Then the salted curd is transferred to the hoops for pressing; the aim of pressing is:

- To form the loose curd particles into shape which is compact enough to be handled;
- To remove additional whey;
- To arrive at the final desired moisture content.

The temperature of the cheese is maintained at just above 21^{o}C during pressing.

The cheddar cheese is then ripened at 10 - 15^{o}C, the ripening usually 3 to 12 months. The longer the storage time the stronger and sharper is the flavor.

Butter manufacturing

- Cream is pasteurized
- Then it is cooled rapidly and age in cold room overnight
- Then the cream is put in a mixing bowl
- Beat the cream at a high speed until butter granules are obtained (Inversion occurs)
- Drain the butter
- Wash the butter granules with chilled brine (for salted butter) until brine washing is clear
- Pack the butter into sterile containers
- Store butter in a cold room

7.3.1 Maintenance & Management Plan

Efforts should be made to improve the nutrition status of available pastures. When this is done, milk yield per cow will increase and the holding capacity might rise to two and half animal units per hectare. If well managed it can supply sufficient energy requirements for grazing animals.

The protein part however needs to be improved. Adaptable legumes, despodium, alfalfa and white clover (uruzi) species can be introduced. Initially trials will have to be carried out in different locations. Regular application of pasture fertilizers is highly recommended.

The small local processing centers quality control technician and other staff should be trained on various aspects that among others would include milk testing, hygienic handling, storage, maintenance of required temperatures and transformation technologies.

Fruit Processing (Focus Banana)

Bananas are classified into categories as beer bananas, cooking bananas and dessert bananas (apple banana). Over half of the total production in Rwanda is used as the main ingredient for making banana beer, one of the most popular alcoholic beverages in Rwanda. Banana is the staple food and its common use is for cooking - 43% of total production. It also produces dessert bananas but the proportion is negligible compared to that of beer bananas and bananas used for cooking.

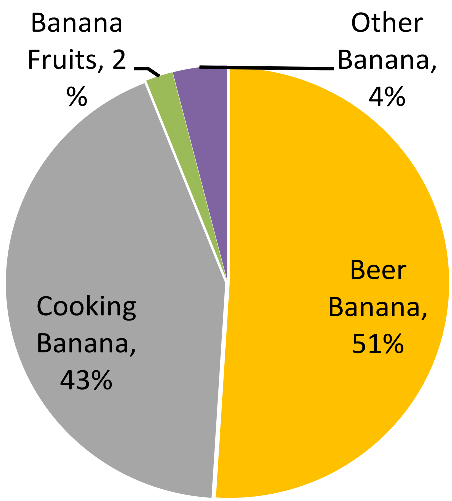


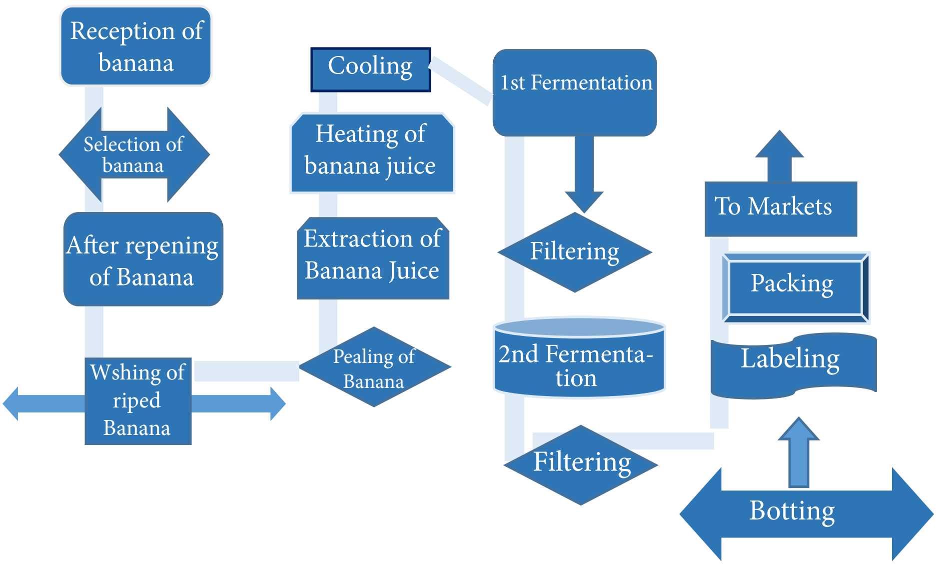
FIGURE 7-2:PIE SHOWING FRUIT PROCESSING

On average, annual banana beer consumption per person is 800g in Kigali, and 3 kg in rural area. Banana beer is the most popular alcoholic drink in Rwanda.

Banana Processing

Brewing bananas are the most widely grown and important cash crop. The brewing bananas are mainly grown as cash crops while the cooking bananas have more household food security significance in Rwanda. The following chart shows the manufacturing process for banana beer produced in a factory.

FIGURE 7-3: DIAGRAM SHOWING BANANA PROCESSING



Target Value Chain Processing in Smart Villages

Banana sector goes through several stages of activities for its products value addition. The existing market focuses mainly on primary and secondary level processing with a small amount of tertiary processing. The primary, secondary and parts of tertiary level processing can be developed for the Smart Green Villages. The detail of activities in each processing level is given below:

TABLE 7-1: ACTIVITY MIX OF BANANA SECTOR

Sector	Processing Level	Activity	End Product
Banana Processing Sector	Primary	Producing	Fresh Bananas
		Harvesting	
		Input Supply	
	Secondary	Packing	Fresh & packed Bananas
		Warehousing/ Cold Storage	
		Transporting	
	Tertiary	Processing Plant	Processed Banana include dried, preserved, chips, juices, Beer and Wine
		Ripening/ Grading	
		Branding	
		Packaging	
		Food Industries	

Maintenance

The process can be made more hygienic and the quality of product improved by following the typical method for making a fermented beverage. This involves the preparation of a wort (which is a boiled starter substrate), addition of a commercial source of yeast, fermentation under controlled conditions (time and temperature) followed by pasteurization to stop the fermentation. The product made by this improved method will have a different taste and appearance to the 'live' beer produced by the traditional method. The improved beer can be bottled and stored and will be consistent from one batch to the next.

Raw materials	Ripe bananas
⇓	
Peel	Peel by hand
⇓	
Remove residue	Use grass to knead or squeeze out the juice. The residue will remain
⇓	
Mix with water	The water: banana juice ratio should be 1:3
⇓	
Mix with cereal flour	Mix with ground and roasted cereals to local taste. For sorghum the ratio should be 1:12
⇓	
Ferment	In plastic container. Leave to ferment for 18 to 24 hours.
⇓	
Filter	Through cotton cloth
⇓	
Pack	In one-litre plastic bottles with cork stoppers or equivalent
⇓	
Store	

FIGURE 7-4 FLOWCHART FOR PRODUCING SMALL-SCALE BANANA BEER PRODUCTION

Equipment required

Beer making does not require any specialist equipment. All equipment used should be of food-grade and should be thoroughly cleaned before use.

- Knives;
- Filter bags (cotton cloth);
- Fermentation vessel (plastic bucket).

7.4 Grain Processing

The purposes of this part of the toolkit are both to improve production of existing products and to stimulate ideas for new products that may have a demand and can be produced at a small scale in Smart Green Villages. However, there is a wide range of cereal flours and bakery products that are produced in Rwanda and it is not possible in a manual of this type to describe them all in details. The high demand for flour and bakery products, especially in urban areas of Rwanda, has led to strong competition as more and more people start to produce these products. Processors should therefore aim at diversifying and producing new types of processed cereal products described in the tables below.

Whole grains and pulses

Stage In Process		Notes
Essential	Optional	
Grain		Harvest and store
↓	Wash/dry	Use wash tanks with clean water to remove stones, leaves, pesticide residues or soil. Wastewater is extremely dirty and must be disposed of in accordance with local pollution standards. Dry the grain if the moisture content is too high
Sort/ grade		Pick out spoiled or mouldy grains, stones, leaves etc. by hand or use a seed cleaner
←	Parboil	In boiling water for 4-48 hours.
← ↓	Dry	To 12-15% moisture depending on the grain The time needed for drying depends on the temperature, humidity and speed of the air and the type of dryer. Check for mould growth, insect contamination and the temperature and time of drying.
Pack ↓		Using an electric sack stitcher to seal paper bags or a heat sealer to seal plastic bags. Check fill-weight and seal.
Label ↓		Check that label is correct for type of product and properly aligned.
Store		Store in a cool dry place away from sunlight.

TABLE 7-2: PROCESS OF DRIED GRAINS

Cleaning and packing dried whole grains and pulses can be profitable business. The costs of labor for cleaning and packing, plus the cost of the packaging materials, result in a higher price for the products compared to similar products that are sold loose in markets. The selling points to attract customers are a safe, high quality product (free from contaminants) and a guaranteed weight in the pack. Promotional information can emphasize for example that products are produced hygienically and are guaranteed free from dirt or stones, mould, insects and other contaminants.

Flour Processing

The process for making flour from maize, rice, millet or sorghum is described below

7.5 Milling Equipment and Maintenance plan

Essential	Optional	Notes
Grain		Harvest and store
↓ ←	Wash/dry	Use wash tanks with clean water to remove stones, leaves, pesticide residues or soil. Wastewater is extremely dirty and must be disposed of in accordance with local pollution standards. Dry the grain if the moisture content is too high
Sort/ grade ↓		Pick out spoiled or mouldy grains, stones, leaves, etc. by hand or use a seed cleaner
Dehull		Remove bran using a dehullers
Mill ↓		To the required particle size
Pack ↓		Fill flour manually or using a bag filler. Seal paper bags with an electric sack stitcher or seal plastic bags with a heat sealer. Check fill-weight.
Label ↓		Check that label is correct for type of product and properly aligned.
Store		Store in a cool dry place away from sunlight.

TABLE 7-3: STEPS OF PROCESS FLOUR

The main items for a small flour mill are a seed cleaner, a dehuller, a mill and packaging equipment and these are described in more detail. The design and construction of feed hoppers, dehullers, mills and other equipment should allow free passage of grains or flour without any recesses that could trap food and lead to contamination. Careful design and construction also prevent the release of dust from equipment.

FIGURE 7-5 MAIZE FLOUR PACKED

Most milling equipment is made from mild steel and it is important that welding is done to a high standard, without holes in the weld or small projections that could trap food. All welds should be ground to a smooth finish. Mild steel easily rusts and it is important that equipment is kept dry to prevent rust from contaminating the grain or flour. A mill or dehuller should be easy to dismantle for cleaning and maintenance. Nuts and bolts that are routinely removed should be made from high quality steel so that threads do not wear out quickly. Worn bolts have the potential to fail and damage a mill or dehuller and injure an operator and metal fragments contaminate the flour.

SOLID WASTE

SOLID WASTE MANAGEMENT

8 SOLID WASTE MANAGEMENT TOOLKIT

8.1 Introduction

This Solid Waste Management Toolkit shall guide the process and design steps for efficient waste management within the village.

8.2 Objective

The objective of Green Village solid waste management is to collect waste at the source of generation, recovery of recyclable materials for recycling, conversion of organic waste to compost and secured disposal of remaining waste.

8.3 Characteristics of Solid waste

Solid waste consists of organic and inorganic waste materials produced by households, commercial and institutional establishments in any rural settlements that have no economic value to the owner. The inorganic wastes are of two types: recyclable and non-recyclable.

General characteristic of solid wastes may be as follows:

- Garbage
- Ash/ Earth
- Paper /Cardboard box
- Plastic / PVC/ HDPE
- Rags / Cotton / Cloth
- Rubber
- Glass

- Leather
- Earthenware
- Wood
- Hay / Straw
- Leaves

8.4 Components and Planning of Solid waste management in Green Village

The following are the components of Solid waste management to be planned and practice in Green Villages:

- Household segregation (organic and inorganic: Recyclables / Non recyclables.)
- Household Storage (In plastic containers);
- Containerized collection (House to house);
- Transportation (Handcart / other types) ;
- Transfer or recyclables / recycling ;
- Treatment and disposal.

8.4.1 Recycling of Waste

Inorganic recyclable solid wastes are to be collected separately from residential houses through sensitization and motivation. Recyclable items would be sold to generate fund. Even some items could be recycled in the village through motivated self-help group i.e. recycling of paper to develop home decorative items.

8.4.2 Step by step Conversion of organic waste to compost

Composting is one of the options for treatment of solid waste. In composting process, the organic matter breaks down under bacterial action resulting in the formation of humus like material called compost. The process can be carried out aerobically or an-aerobically. Aerobic process is quicker and accordingly it is preferred. Following are salient issues of windrow method of composting.

- Aerobic process; to keep moisture content between 45 and 50%; regular suitable (every 6th days).
- Average time requirement: 21 days.
- Maturation time: 15 days (max).
- Average Compost production: 50% or raw input
- Pathogen free due to rise in temperature in windrows.
- Aesthetically acceptable.
- Average NPK: 3% of compost.
- Average Application rate: 4MT/ha.
- Affordable to farmers
- Decentralized small plants preferred
- Environmental cost consideration.

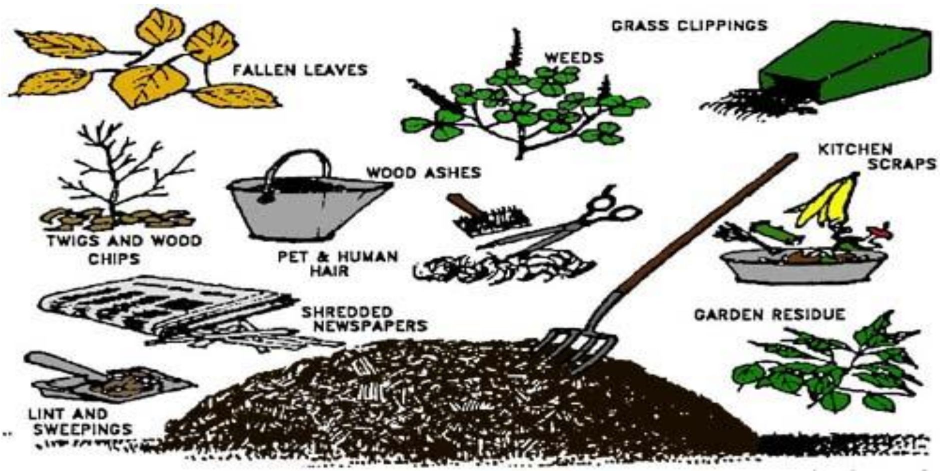
8.4.3 Household Level Composting

- Anaerobic process
- At each household two manure pit / trench should be dug.
- The size of the pit / trench will depend on the quantity of refuse to be disposed per day.
- Each day the garbage, cattle dung, straw, plant and agricultural waste are placed in the pit / trench.
- When the pit / trench is filled up, it is closed with earth cover.
- Every day after disposal of waste in pit / trench, little dry earth is to be spread to prevent fly breeding and also door problem.
- In 5-6 months' time, the waste is converted into organic manure.

8.4.4 Vermin Composting

- Vermin composting involves the stabilization of organic solid waste through earth worm consumption which converts the material into worm castings.
- Vermin composting is the results of combine activity of microorganism and earthworms.
- Vermin compost unit can be developed at household level. It may require only 2 square meter area per family.
- Vermin composting unit can be developed at community level.
- Easy to operate and maintained.

Figure 8-1: Vermin Composting



8.4.5 Secured Landfill

The non-recyclable inorganic waste could be disposed by secured land filling operation. The site for secured landfill in the Green Villages are to be identified and marked in the Layout Plan of the Village and should be away from settlement area. The salient components of disposal of solid waste in secured land fill site are as follows:

- Filling of low yield land
- No risk of ground water and surface water pollution
- Compaction of fill
- Earth cover after filling
- Land reclamation
- Landscape development
- Use of land for horticulture, playground, recreational park etc.

8.5 Maintenance & Management Plan

The local beneficiaries of the Smart Green Villages will be trained on maintenance and importance of solid waste management.

In order to properly manage solid waste with minimum effort and cost, focus must be on management at the household and community level. The following steps may be followed for introducing community based Green Village solid waste management system.

Step 1: Information collection

- No. of household;
- Total population;
- Details about shops, schools, commercial establishments etc.
- Village maps;
- Existing system and practice of waste management;

- Quantity of solid waste generation;
- Details about vacant land availability;
- Details and activities of NGOs, Self-help groups etc.

Step 2: Participatory planning

- Involvement of community for data analysis.
- Community would be informed and motivated about adoption of better SWM in the Green village.
- Preparation of action plan with community participation.
- Community must be informed about sustainability of programme.

Step 3: Preparation of action plan

- Social mobilization and awareness generation
- Technology options
- Operation and maintenance
- Sustainability of the management system

VILLAGE KNOWLEDGE HUB TOOLKIT

9 KNOWLEDGE HUB TOOLKIT

9.1 Introduction

There is a need for designing and building Smart Villages which are independent in terms of providing the services and employment and yet well connected to the rest of the world. The Knowledge Hub Toolkit shall guide the process and design steps for development of SMART village.

9.2 Objective

The main aim of Village Knowledge hub is to have a SMART Green village which will be part of the following:

- Centre for learning and innovation
- To train farmers in modern farming techniques
- Information hub will help transform agriculture into a viable market-oriented venture
- Community knowledge centres complete with computers and internet connection to help farmers get information on markets
- "Smart technologies" shall create more efficient systems and better informed communities and village residents.
- Economic development and the creation of jobs.
- Promoting resource efficiency and mitigating climate change.
- Running Green villages more efficiently
  Supporting communities.

9.3 Planning & Implementation of Village Knowledge Hub

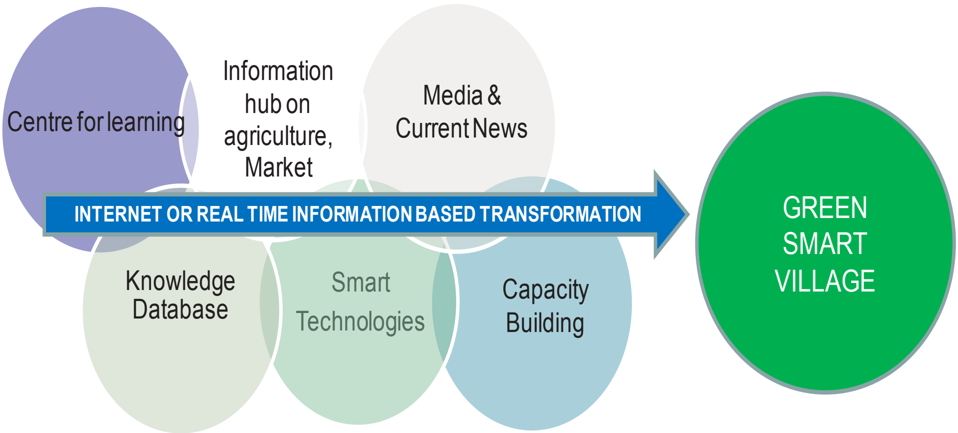


FIGURE 9-1: INTERNET OR REAL TIME INFORMATION BASED TRANSFORMATION

Villagers shall be empowered by the presence of a hub delivering ICT and non-ICT products and services on many grounds. The main activity for a Smart Green Village includes:

- Obtain valuable information through the internet on local or national political issues or on work-related issues, such as agricultural prices;
- Villagers can communicate through access to new communication technologies. They can share news with families and friends, network and share with business partners, develop information and broadcast it on the web, and make their opinion heard at different levels on various online platforms and forums;
- People from rural areas save money and time as products and services, such as administrative documents, are made available via their Village Knowledge Hub (ICT/ telecentre), thus eliminating the need to travel to large towns to access them;

- The Village knowledge hub services can also increase employment opportunities in rural areas:
    - ICT skills enable the local population to apply to more types of jobs as skilled workers. These skills can also support villagers to open new enterprises, or strengthen the management capacities of existing ones.
    - Village Knowledge Hub contributes to the reinforcement and creation of local micro, small and medium enterprises (MSMEs).
- Finally, by providing an online and physical platform to buy and sell services and products, the Village Knowledge Hub increases the possibilities for businesses to sell and adapt themselves to local demands.

9.4 Design Steps to Develop Village ICT Smart Plan

The design steps shall arrive at a framework that village communities can use to be a SMART village. It has been developed in the context of villages in Rwanda as Village Knowledge Hub with a goal to rebuild and remain economically and socially sustainable. There are four elements to be considered while designing this framework:

1. **Introducing Technology and Creating Awareness in Green Villages:** Initially educational institutions (schools) and market places can be the target areas. School students and rural people shall be allowed to use the computer for writing their name and print it free of cost from the ICT community centres. 'Announcement about the computer and knowledge centre' as a campaign shall also be part of introduction and awareness development activities.
2. **Capacity Building and Skill Development as Foundation Work:** As introduction and awareness development exercise reached an expected stage, computer training can be started. The first group to be targeted is the village youth having basic literacy. To be guided by the baseline study and ongoing project activity analyses as part of the Green Village

Development. Along with village communities, students and teachers, computer shall be introduced among members of governing boards of schools in the Green Villages

3. **Gather Rural Information and Creating Awareness in Green Villages:** This stage shall include the tasks to collect information on Green villages and input in the computers. The process can be assigned to a survey group including a member from village community whose responsibility would be to collect information from Green village homes and village resources and easy access to markets through online feed for the creation of the database. The database is to be updated quarterly and regularly. The well trained group can also be engaged in training and grooming the new young village group for the job.

4. **ICT Database as Knowledge Base and Information Source:** Village residents and other interested parties can obtain necessary instant information from the database. For example, if anyone wants information, like access timely information on farming, crop pricing and the market situation in general, the database and online access can be used instantly to provide the information

9.5 Maintenance & Management Plan

The Local beneficiaries of the Smart Green Villages will be trained on the maintenance and uses of ICT highlighted below:

Maintenance & Supervision: The project shall incorporate provision of sharing information on database in the community level meeting. People of the locality shall be aware that they could use the database and online access as and when necessary. These shall open to all without any restrictions. Feedbacks can be regularly collected and documented.

Community Involvement: The bottom up exercise at the pilot phase shall involve local youths and local residents to gather information, and provide ICT access through Knowledge Centres in different Green villages. That is, the rural youth with community participation shall design the database, collect information and develop database.

Management: The project shall be supervised or managed by a team including the village residents. They can be chosen by specified criteria, like one headmaster, one religious leader, one ex-chairman and others from implementing organization. This committee shall act as the Implementation Team of the project at local level. A local youth village resident shall also be engaged in the rural database activity in different capacities.

CONCLUSION

10 CONCLUSION

The Green Village project offers an excellent example of how investing in more sustainable environment and natural resource management can reduce poverty and improve broader human well-being. These communities run projects that contribute to poverty reduction, enhancement of sustainable use of environment and natural resources, and increased resilience and adaptability to climate change. Therefore, a Toolkit was developed as a guiding document for users and other stakeholders.

The Toolkit describes seven of the new technologies used in the Green Village and what tools would make them a Green 'SMART' Village.

The toolkit provided the following guiding documents:

- Step by step design manuals for the set of technologies used in Green Village ranging from rainwater harvesting and biogas systems to terracing and tree planting
- Steps in using "Smart" Green Village to the incorporation of appropriate Information Communication Technology (ICT) capabilities for the Green Villages.
- Step-by-step guidance to relevant National and District officials as well as the villagers and Private Sector stakeholders in the design, development and establishment of Green Smart Villages
- Step-by-step guidance to residents of Green Smart Villages on the individual and corporate ownership, management and maintenance of Green Smart Village fixed (houses, infrastructure etc.) and consumable (water, biogas, etc.) assets

This 'SMART' Green Village Toolkit shall provide users with the basic strategies and tactics necessary to transform the existing villages into SMART Green village, low carbon institutions with the capacity to address livelihood, climate change, increase resource efficiency, enhance ecosystem management and minimise waste and pollution.

The Local beneficiaries of the Smart Green Villages will be trained especially on the maintenance, uses and Importance of the Toolkit Components.

To effectively support this journey and other transformative processes in the Green Villages, the Toolkit was structured in such a way that it is flexible, can be used in many ways, including separate training sessions, with a focus on the sustainable planning, design, development and management of the Smart Green Village and how this can be replicated in any other districts.