POTENTIAL FOR RAIN WATER HARVESTING IN TEN AFRICAN CITIES:
A GIS Overview

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EXECUTIVE SUMMARY

(1st Paragraph from Prof. Bancy's report)

(2nd Paragraph)
This report describes the mapping by GIS, of the RWH Potential in ten African cities. The project provides an advocacy tool, which shows the expansive opportunities for RWH in African capital cities in ten countries, namely Botswana, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe. It produced a GIS database that captures major features associated with RWH in "built-up areas". The baseline thematic maps were then used together with mean annual rainfall and catchment area efficiency(runoff coefficient) to show in volume the RWH potential for the targeted interventions mechanism grouped as;

1. Rooftop RWH
2. Surface runoff RWH
3. Ground Water Recharge RWH
4. Forest Water Recharge RWH

The project therefore produced a total of 35 thematic base-maps, 10 rain water harvesting maps and calculations in volume of the potential RWH for the four different RWH domains.

INTRODUCTION

(In Prof. Bancy's report)

PROJECT OBJECTIVES

The main objective of this project is to demonstrate the huge potential for RWH in African cities and therefore provide a tool for advocacy and decision support for RWH in Africa.

SPECIFIC OBJECTIVES

Development of a GIS database of RWH potential in 10 African cities, for selected RWH technologies (Rooftop RWH, Surface runoff RWH and Ground Water Recharge RWH) Provide city level GIS database showing RWH potential for Nairobi (Kenya), Gaberone (Botswana), Harare (Zimbabwe), Dar es Salaam (Tanzania), Lilongwe (Malawi), Kigali (Rwanda), Kampala (Uganda), Maputo (Mozambique), Lusaka (Zambia) and Addis Ababa (Ethiopia).

DEVELOPING THE GIS DATABASE

Identifying Mappable RWH technologies

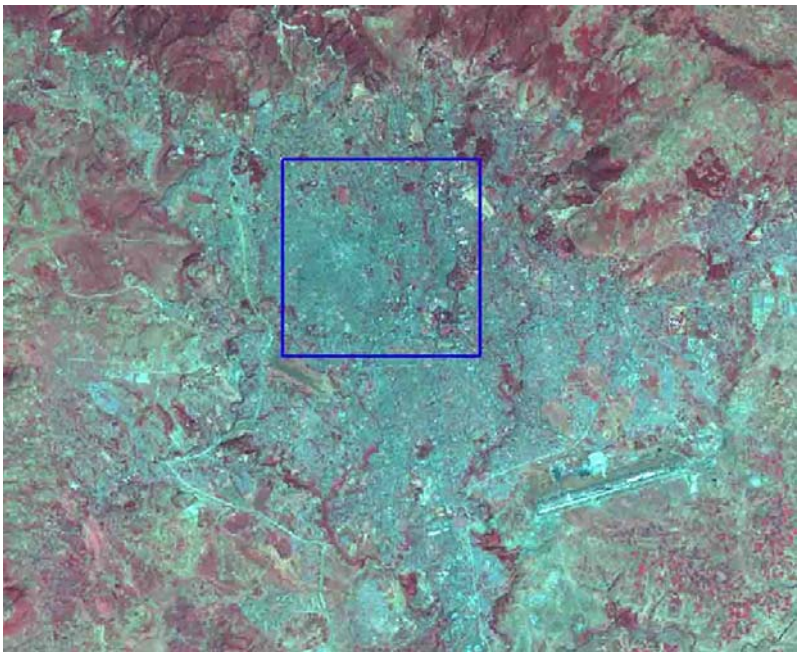
The first task was to identify and decide on which RWH technologies to be mapped at city level. This was to aid in capturing the relevant data and scale. After wide consultations the project agreed to map four RWH technologies namely

1. Rooftop RWH
2. Surface runoff RWH
3. Open Ground Water Recharge RWH
4. Closed Ground Water Recharge RWH (Forests)

Relevant GIS data associated with the RWH technologies chosen were identified as high resolution quickbird satellite imagery, rainfall data, and the RWH coefficients.

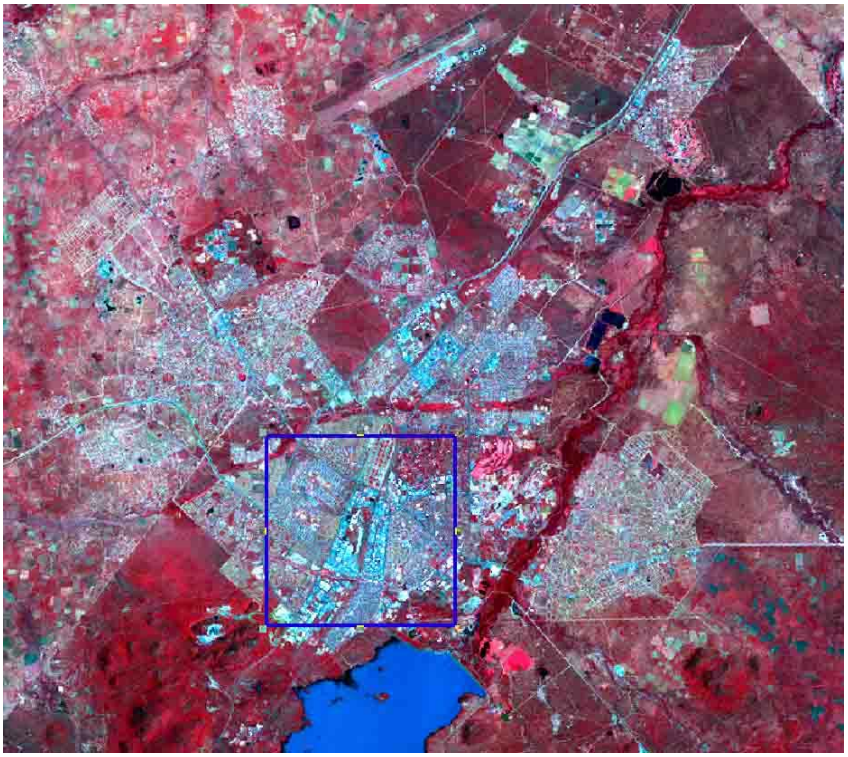
Cities Area Identification

Identification of a 5KM by 5KM city image proved to be a trick affair. Since no GPS coordinates of the area of interest were available, landsat satellite image had to be used to identify built up areas. Combining the right band combination to highlight built up areas and choosing a 5KM by 5KM area from the image did this.

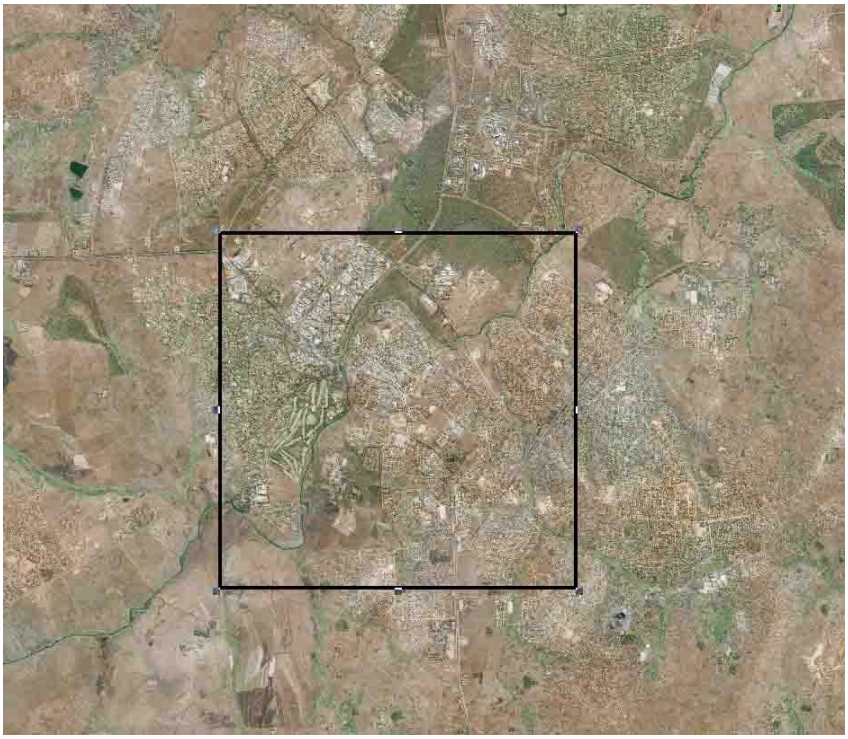


Addis Ababa

Dar es Salaam



Gaberone



Lilongwe

Maputo

Data Acquisition

The Quickbird satellite, launched in October 2001, acquires black and white images with a resolution of **61 cm** and colour images (4 bands) with a resolution of **2.44 m** covering a surface area of **16.5 km** x **16.5 km.**

The Basic products are sold by scene, while the Standard and Orthorectified products are sold per km2 with minimum and maximum acquisition surface areas depending on whether the image is from the archives or has been programmed

The project therefore went for a 25KM² recent images for each city of interest as shown in the appendix.

Runoff coefficients and area factor were from the UN-habitat Urban rainwater harvesting manual while mean annual rainfall data was derived from WorldClim dataset?

Data Processing

Data Capture

Data capture was done in Arcview environment and involved digitizing the features including buildings, roads, waterbodies and forests. Apart from buildings which were captured as polygons, the remaining items were captured as lines hence the procedure described below.

Editing the roads and conversion to polygons.

With all the roads having been capture using lines in Arcview GIS, they were then taken to ArcGIS workstation for editing. The whole process of editing involved closing the gaps that may have occurred during the capturing exercise and hence make them continous lines. The purpose of this was to make the conversion to polygons possible. Therefore, Still in ArcGIS workstation, the conversion to polygons was then done. The conversion to polygons enabled area computation which is a major input in calculation of rain water harvesting volumes. The same procedure was also carried out to all the other features that had been captured in lines. These were the waterbodies and forests. At the end of this exercise, all the features were now in polygons and therefore using MILA Utilities tool in Arcview, the areas of all these polygons were computed.

Capturing of the non-builtup areas.

At these point, all the other features .i.e roads, forests, waterbodies and buildings, were to be used to get the nonbuiltup areas polygon. The procedure followed here was to first merge all the other features into one theme. Then a new polygon theme was created which had to have the entire area of $25km^{2.}$ Its from this new polygon theme that the other features, that had been merged, would be erased from and hence get a new polygon theme which would represent the non-builtup areas. The area of this new feature was then calculated too. Upon completion of this precedure, all the necessary features were now ready for analysis.

Data Analysis (Editing the theme tables).

The individual tables of all the features that had been captured had to be edited by creating fields to represent the attributes needed for these features. The attributes required for these features were area, runoff coefficients, area factor, annual rainfall and harvestable volume. The sources of the data for all these attributes were;

- The areas of each and every feature were calculated using MILA utilities in Arcview.

- Their runoff coefficients were from the UN-habitat Urban rainwater harvesting manual.
- Area factors were also from the UN-habitat Urban rainwater harvesting manual.
- Annual rainfall data for the area were from Africa rainfall dataset from World Clim.
- The volumes of the harvestable rainwater from these surfaces were calculated by multiplying all the above factors i.e (a) to (d).

PROJECT OUTPUTS

The RWH technologies in the project are;

- Rooftop RWH (Buildings)
- Surface runoff RWH (Roads)
- Open Ground Water Recharge RWH (Open spaces)
- Closed Ground Water Recharge RWH (Forests)

(Each technology is well explained in Prof. Bancy's write-up).

Maps

The project produced 35 base-maps and 10 RWH maps as below.

Feature	Number of Maps
Rooftops	10
Roads	10
Open Ground	10
Forests	5
RWH Maps	10

Figures

Using the relevant coefficients, the project calculated the potential volume of water that can be harvested from the four technologies. They are as below.

CITY	UNIT	BUILDINGS	ROADS	OPEN GROUND	FOREST
Gaberone	Area (m^2)	3,416,889	2,984,939	18,545,852	59,873
	Volume (m^3)	1,330,194	956,971	2,123,500	4,113
Lilongwe	Area (m^2)	2,393,250	1,361,337	19,361,813	1,758,679
	Volume (m^3)	1,759,637	824,289	4,187,005	2,28,188
Nairobi	Area (m^2)	6,194,180	2,661,532	15,568,782	571,428
	Volume (m^3)	4,612,186	1,632,051	3,409,563	75,086
Kigali	Area (m^2)	694,604	2,428,493	15,437,801	206,601
	Volume (m^3)	5,833,285	1,679,546	3,813,137	30,618
Lusaka	Area (m^2)	4,907,157	1,713,116	18,386,379	-
	Volume (m^3)	3,474,512	998,918	3,828,963	-
Dar es Salaam	Area (m^2)	5,374,249	1,264,615	13,844,050	380,766
	Volume (m^3)	5,029,491	974,639	3,810,575	62,883
Maputo	Area (m^2)	7,225,306	1,856,428	13,766,318	-
	Volume (m^3)	4,784,236	1,012,310	2,680,990	-
Harare	Area (m^2)	5,284,998	2,583,767	17,107,877	-
	Volume (m^3)	3,688,136	1,484,891	3,511,392	-
Kampala	Area (m^2)	6,694,590	1,396,431	16,874,383	-
	Volume (m^3)	7,414,593	1,273,684	5,496,830	-
Addis Ababa	Area (m^2)	11,649,120	2,021,400	11,349,265	-
	Volume (m^3)	11,436,523	1,634,301	3,277,100	-

LIMITATIONS

Due to cost implications the project could not afford a scene of quickbird imagery and had to resort to the smallest available image that is a 5KM by 5KM image.

The quickbird satellite image though of high resolution, could not enable the identification of catchment areas characteristics which is a required parameter in the calculations. These include the different types of roofing materials, slope of the roofs, road surface and pavement characteristics. The projected RWH Potential was calculated without the input of these parameters.

REFERENCE:

1. Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2004. The WorldClim interpolated global terrestrial climate surfaces. Version 1.3. Available at http://biogeo.berkeley.edu/

2. UN-habitat Urban rainwater harvesting manual

3. DigitalGlobe, 2004-2005 (www.digitalglobe.com)

APENDIX I. TABLES

Table 1. Satelitte image acquisition data

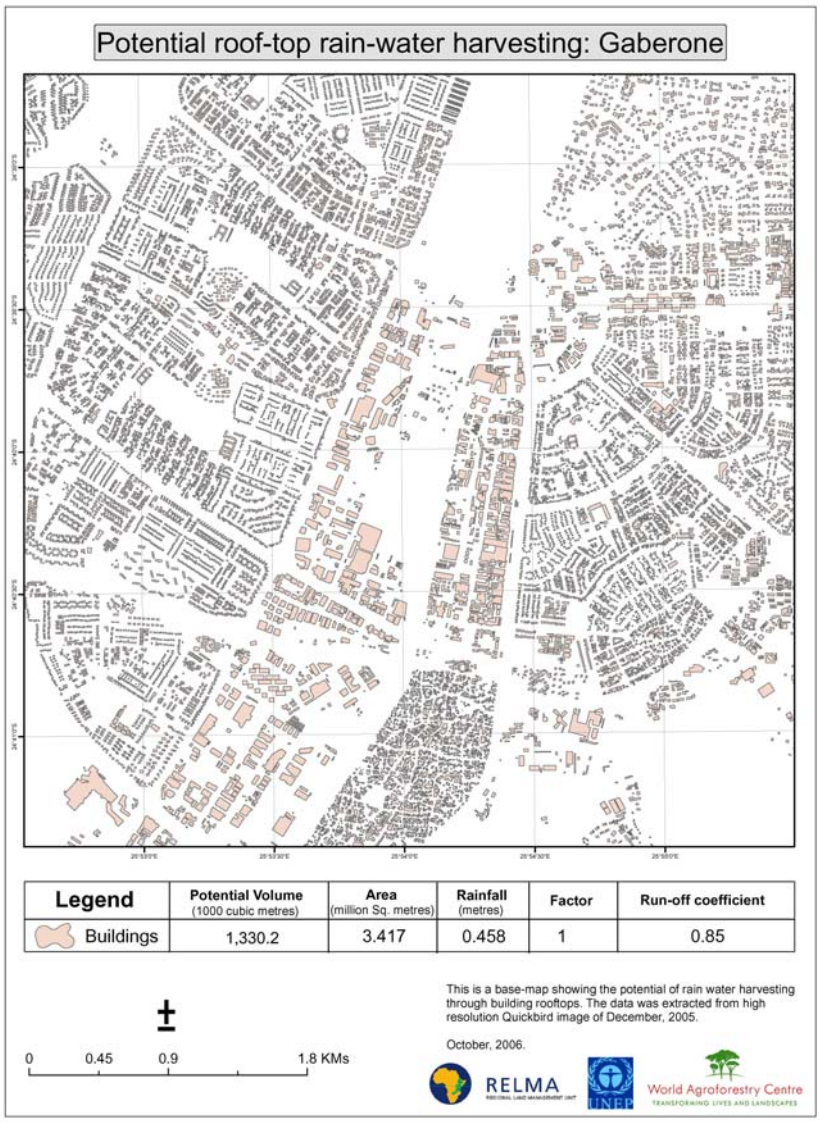
NAME OF CITY	ACQ DATE
Kampala	2004-02-11
Maputo	2005-04-01
Addis Ababa	2005-11-08
Harare	2005-06-22
Gaberone	2005-04-13
Dar es salaam	2006-02-09
Lilongwe	2005-05-30
Nairobi	2005-10-03
Kigali	2004-12-26
Lusaka	

Table II. Data processed

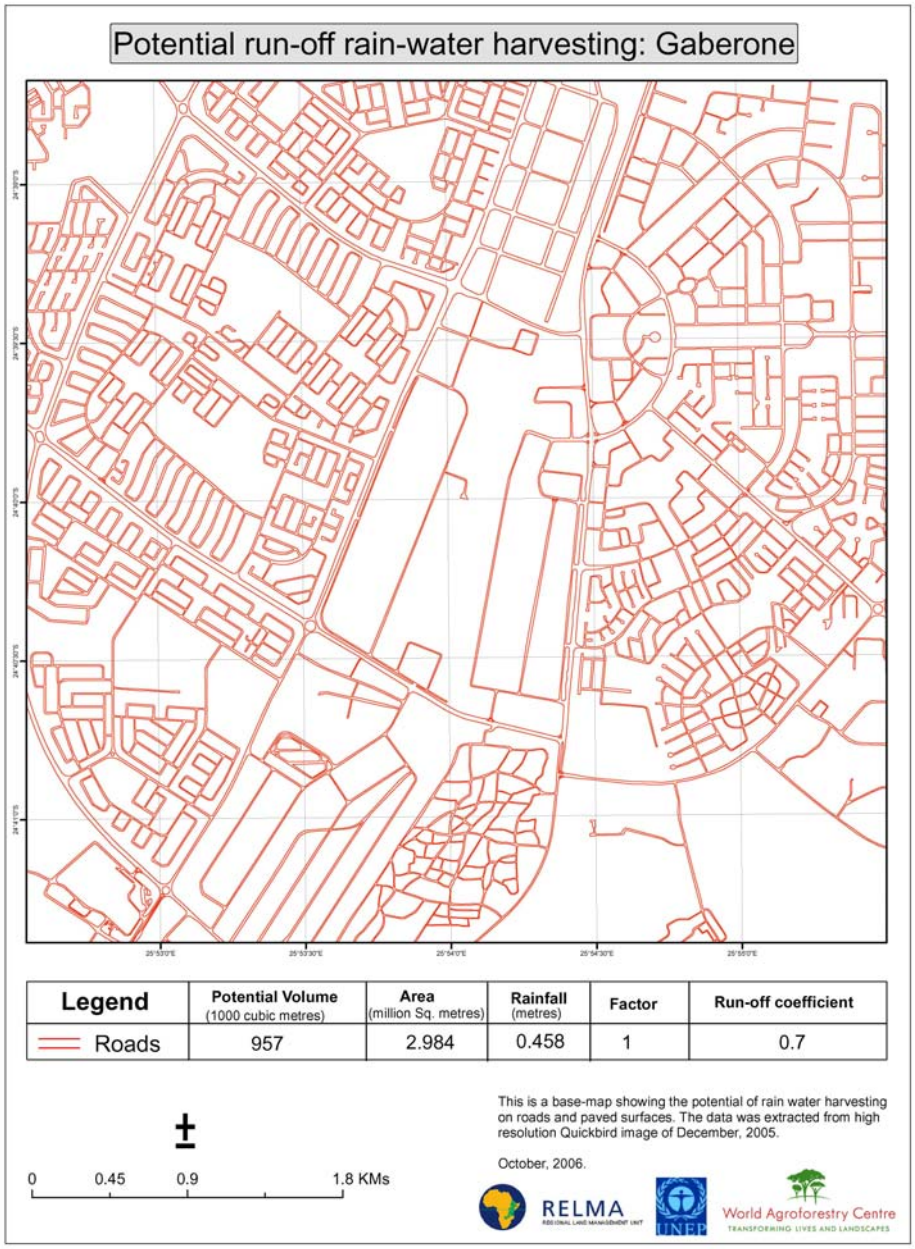
CITY	Roads		Buildings		Open Ground		Forest	
	Captured	Edited	Captured	Edited	Captured	Edited	Captured	Edited
Gaberone	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lilongwe	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Nairobi	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dar es Salaam	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Harare	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Kampala	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Maputo	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Addis Ababa	Yes	Yes	Yes	Yes	Yes	Yes	-	-
Kigali	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lusaka	Yes	Yes	Yes	Yes	Yes	Yes	-	-

APENDIX II. BASE MAPS

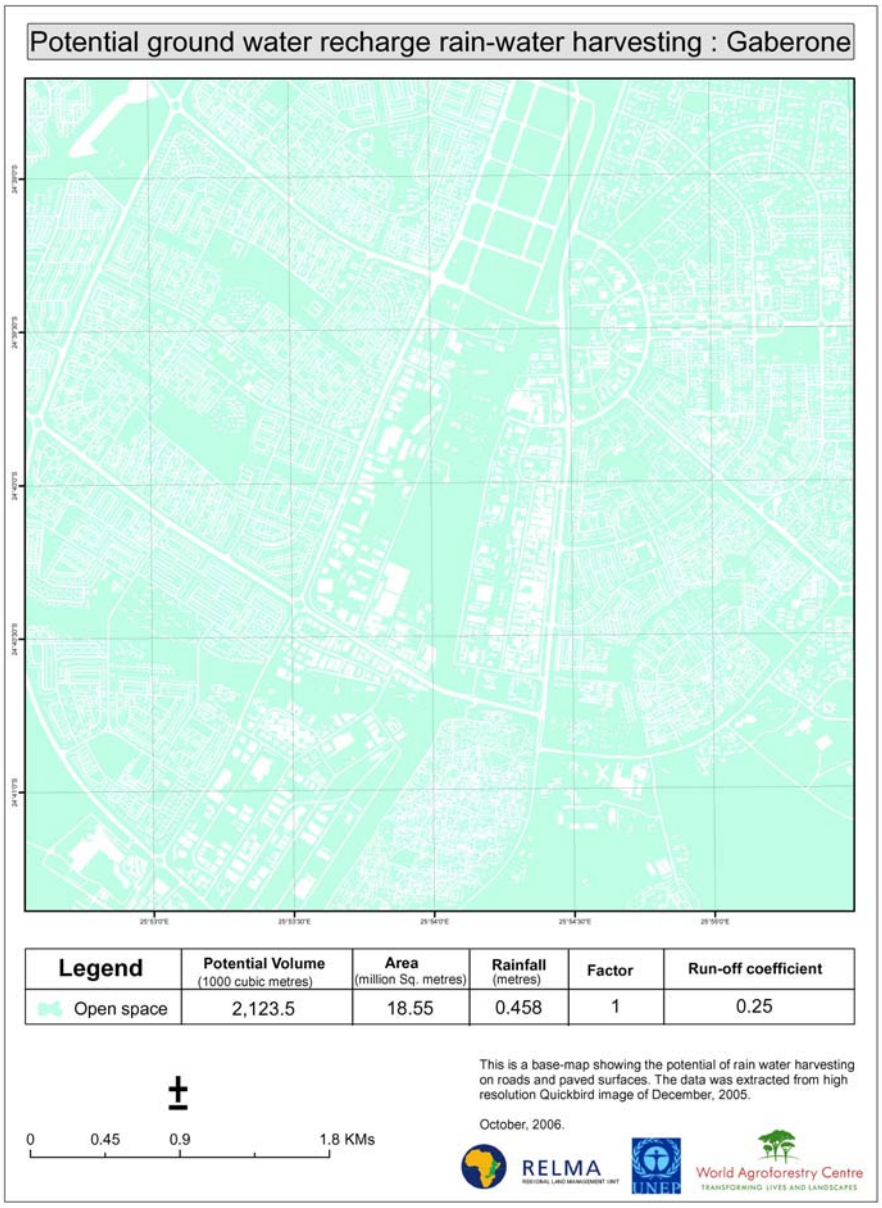
Project Base Maps: Gaberone



Buildings Base Map, Gaberone

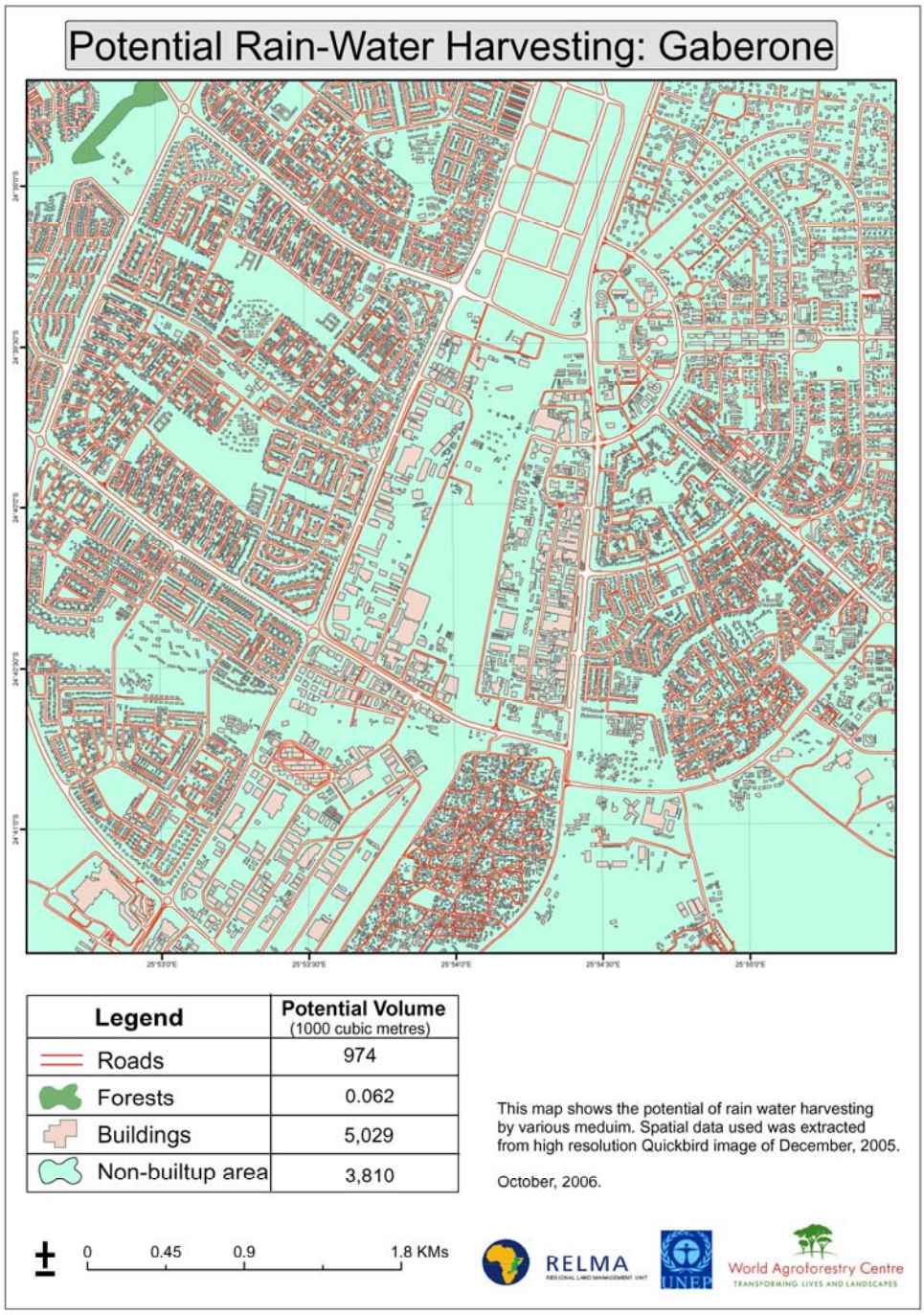


Roads Base Map, Gaberone

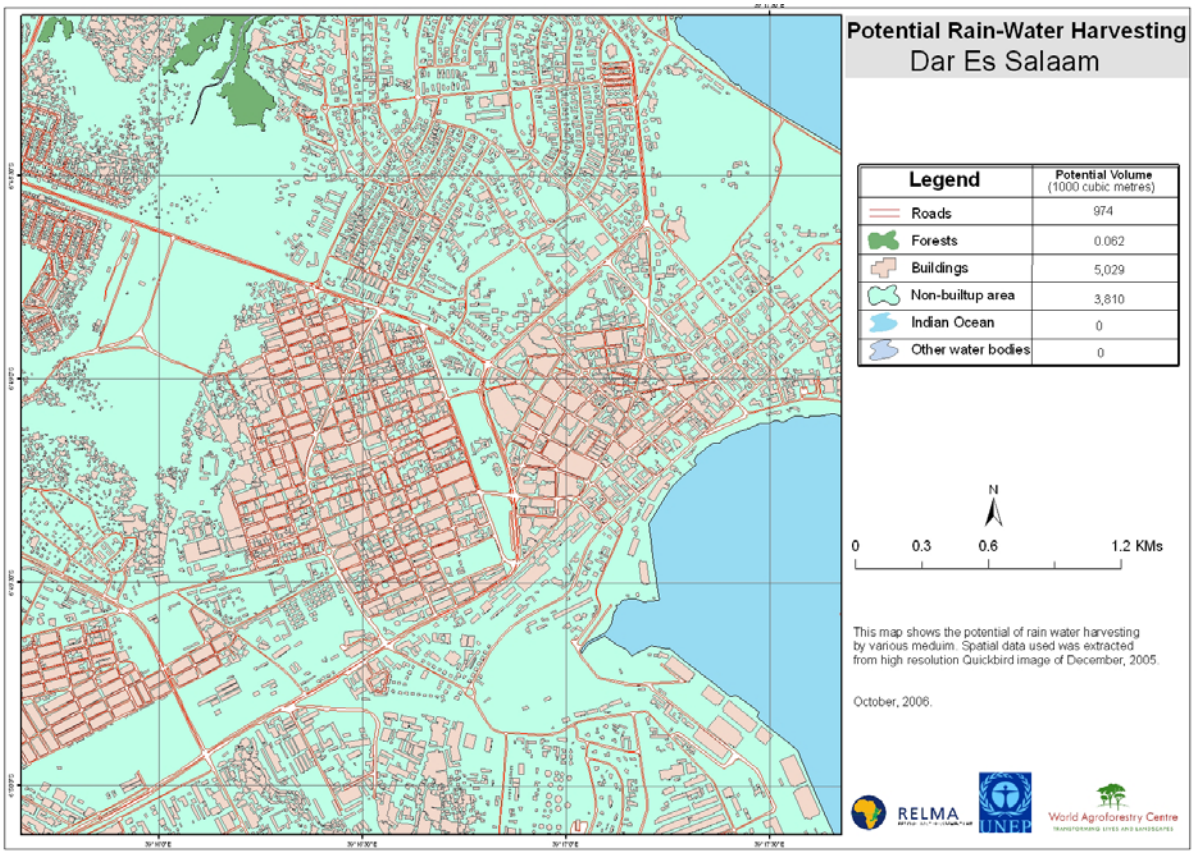


Open Spaces Base Map, Gaberone

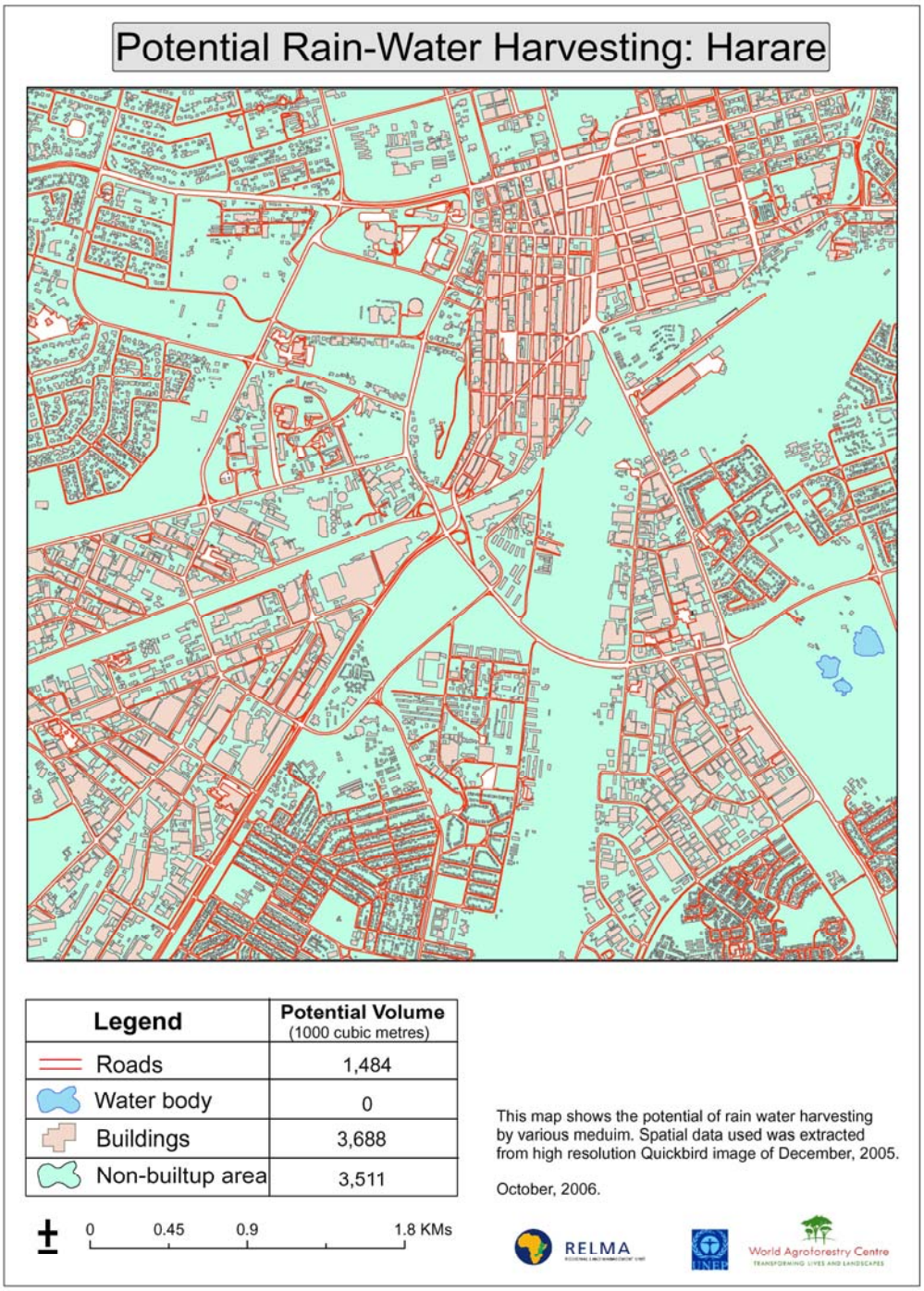
APENDIX III. RAINWATER HARVESTING MAPS



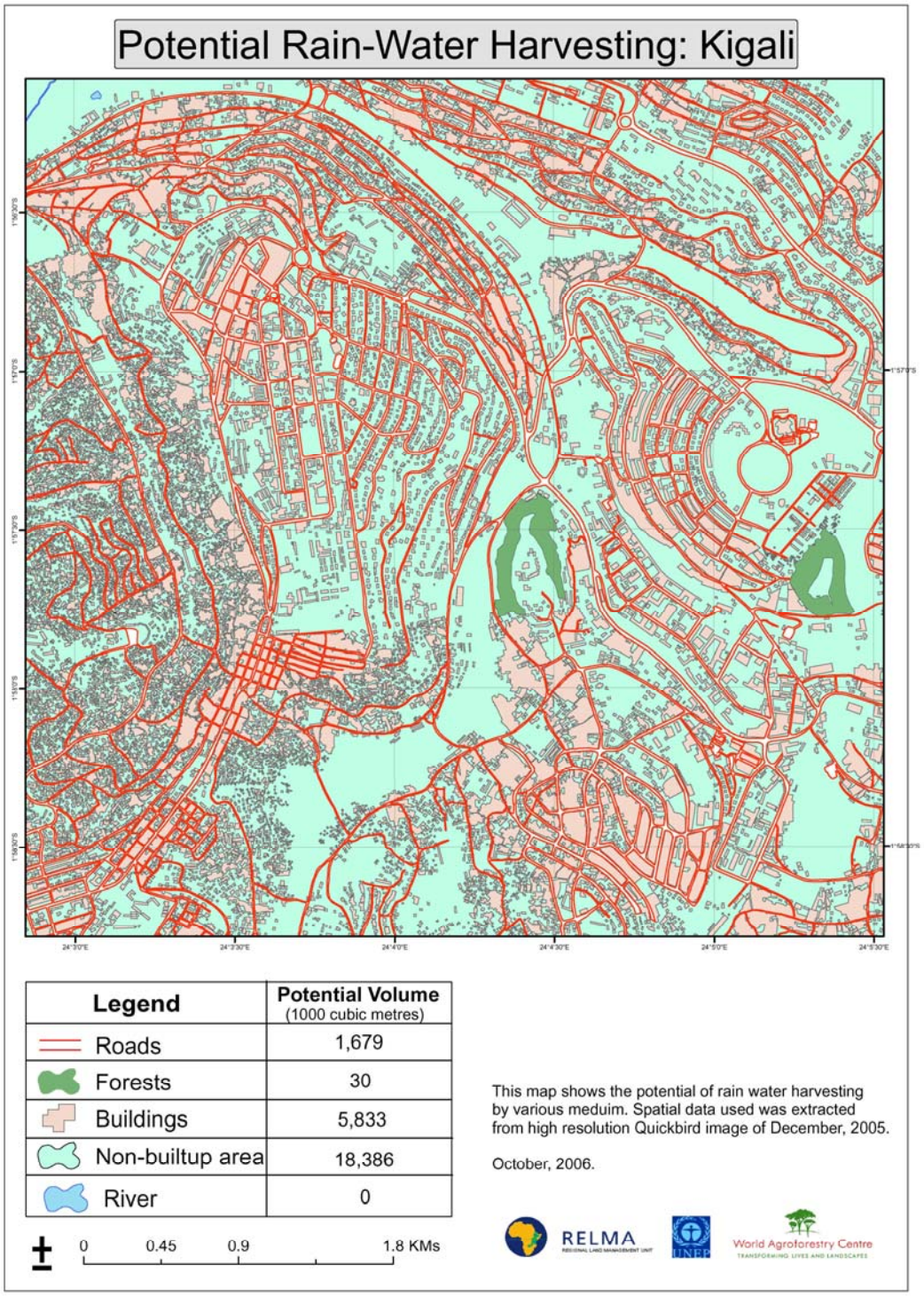
Garberone RWH Map



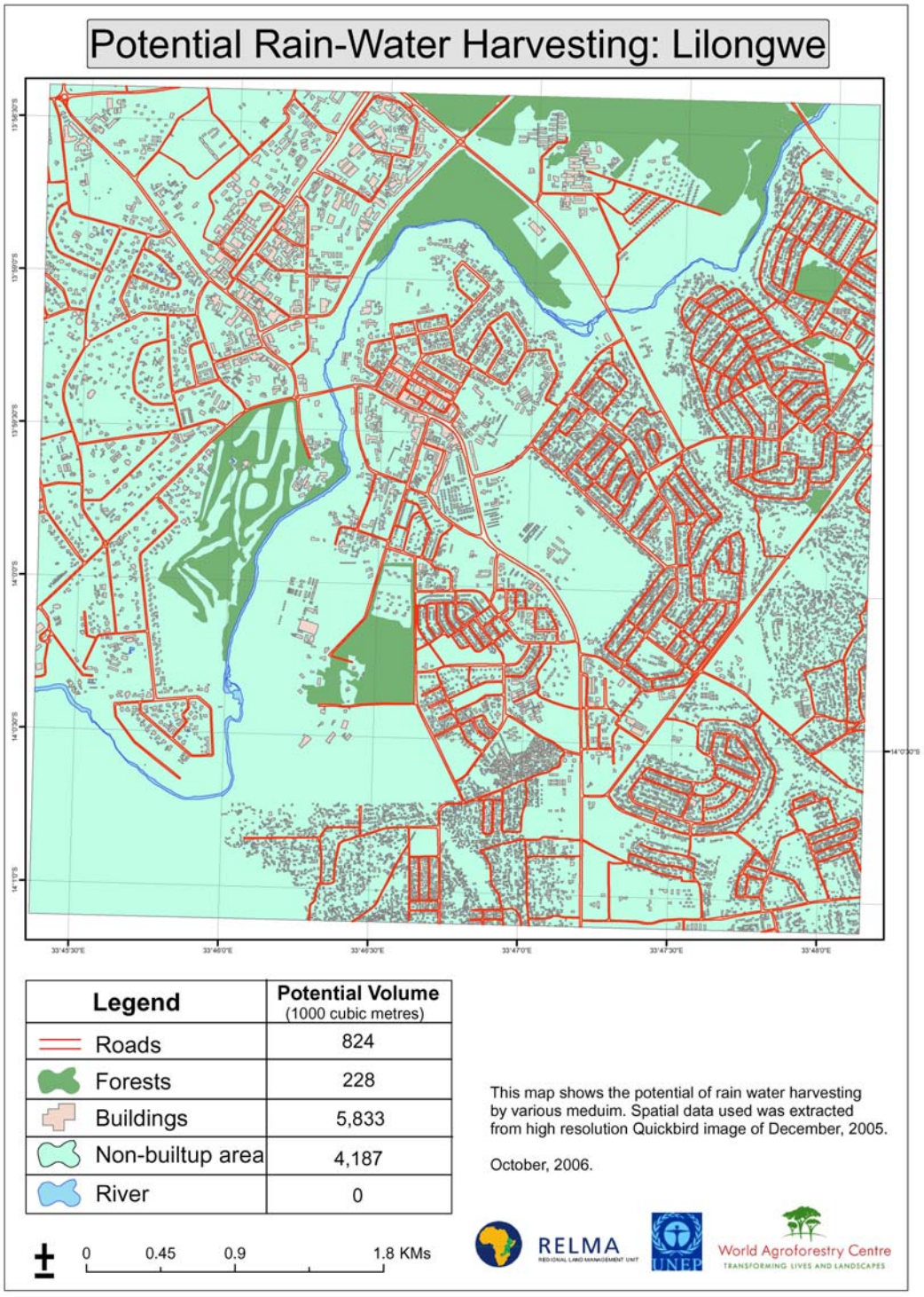
Dar es Salaam RWH Map



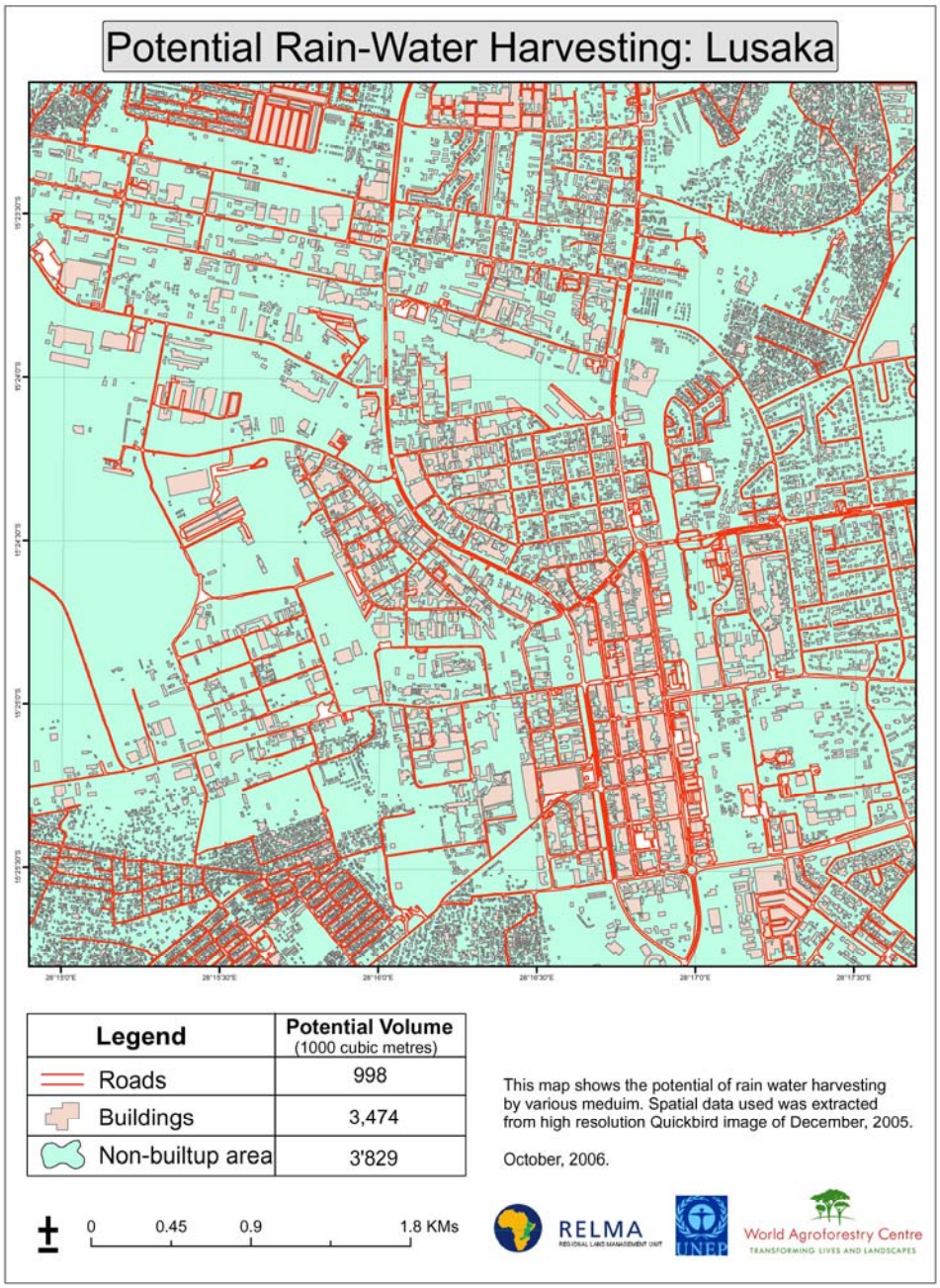
Harare RWH Map



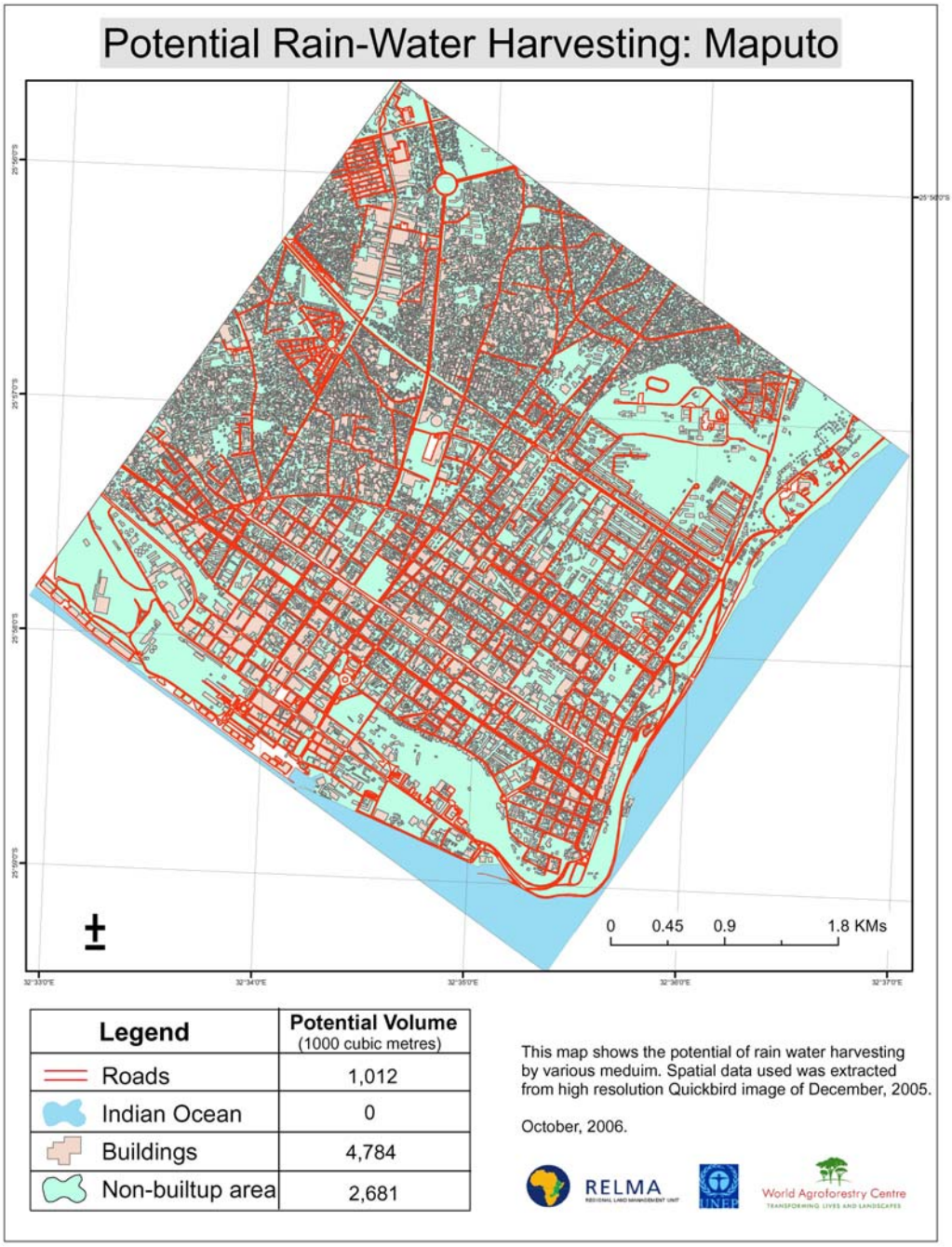
Kigali RWH Map



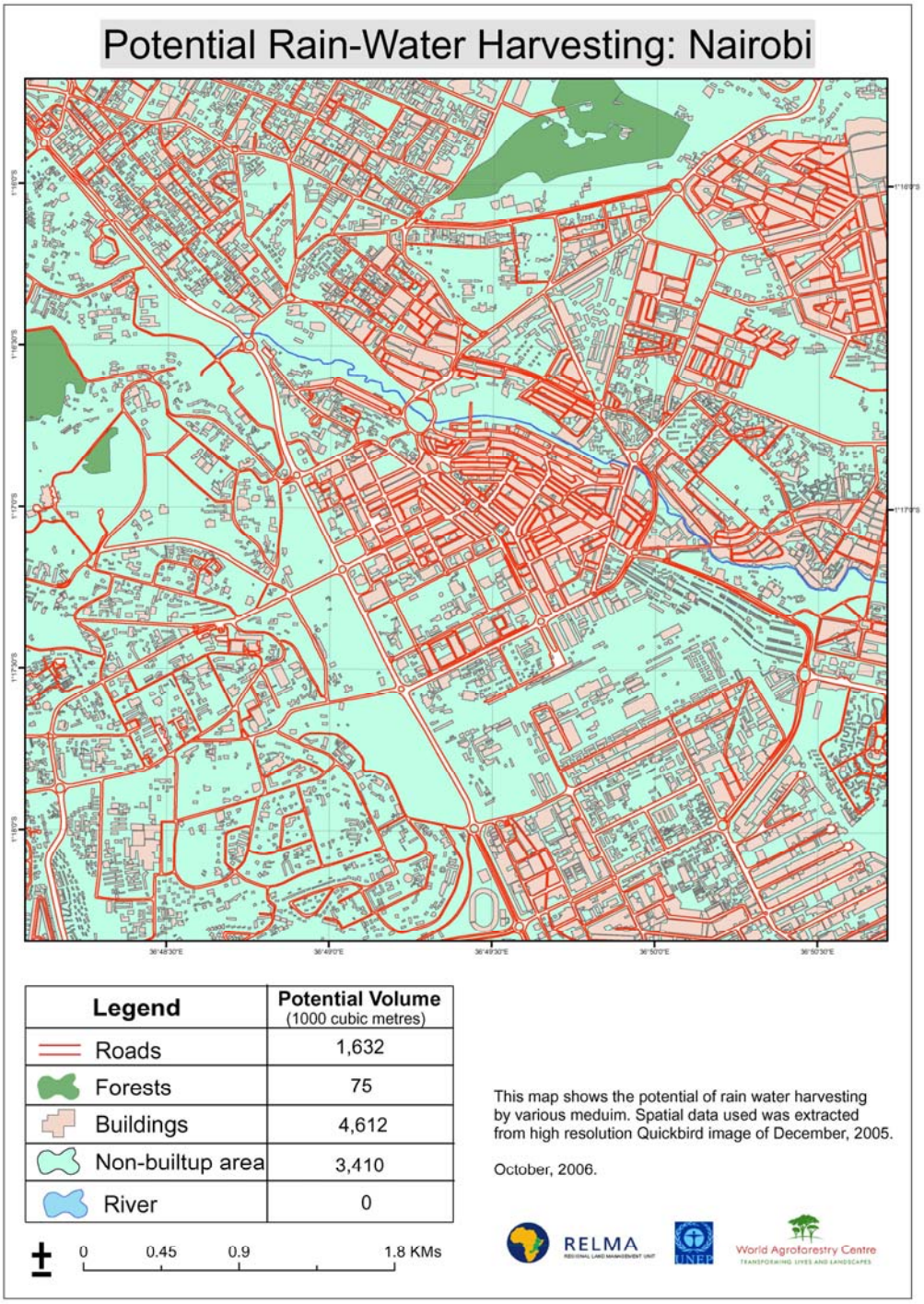
Lilongwe RWH Map



Lusaka RWH Map



Maputo RWH Map



Nairobi RWH Map