River water pollution in Addis Ababa, Ethiopia: A comparison of pollutant levels between Dry/Wet Season and Level of Urbanization

Presented by: Dagnachew Adugna

Presented at the University of Michigan, USA

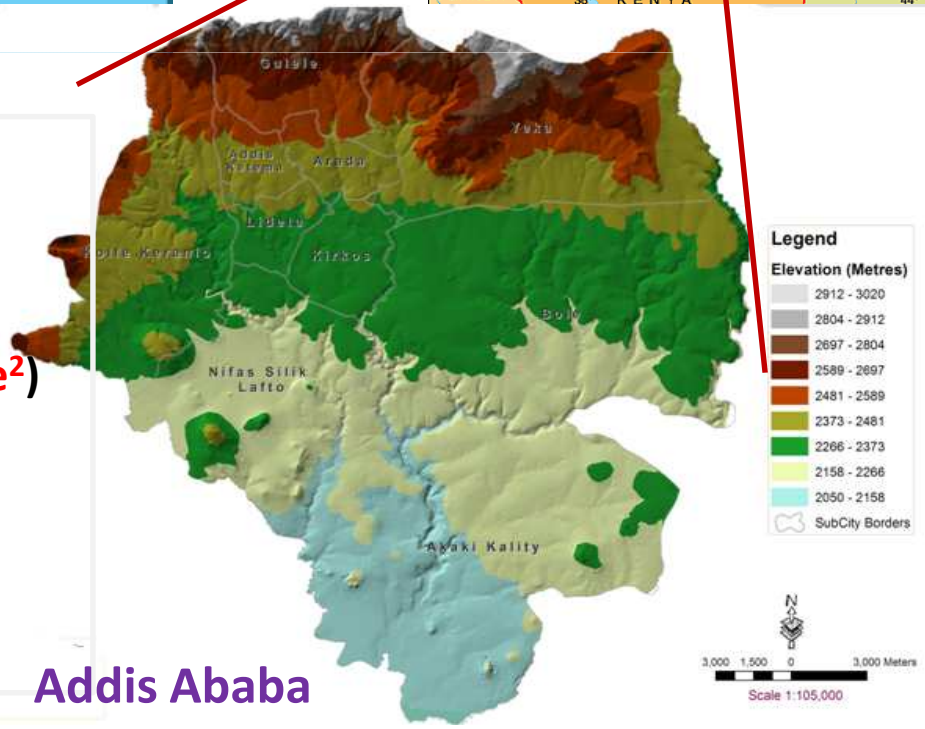
Dec. 05, 2016

Contents of the presentation

- Introduction
  - Background
  - Research gaps
  - Research Objectives
- Methodology
- Results & Discussion
- Implications

Acknowledgment

Location map of Addis Ababa relative to Ethiopia



Area: 520 Km^2 (200.77 mile^2)

Population : ~4 million

Addis Ababa

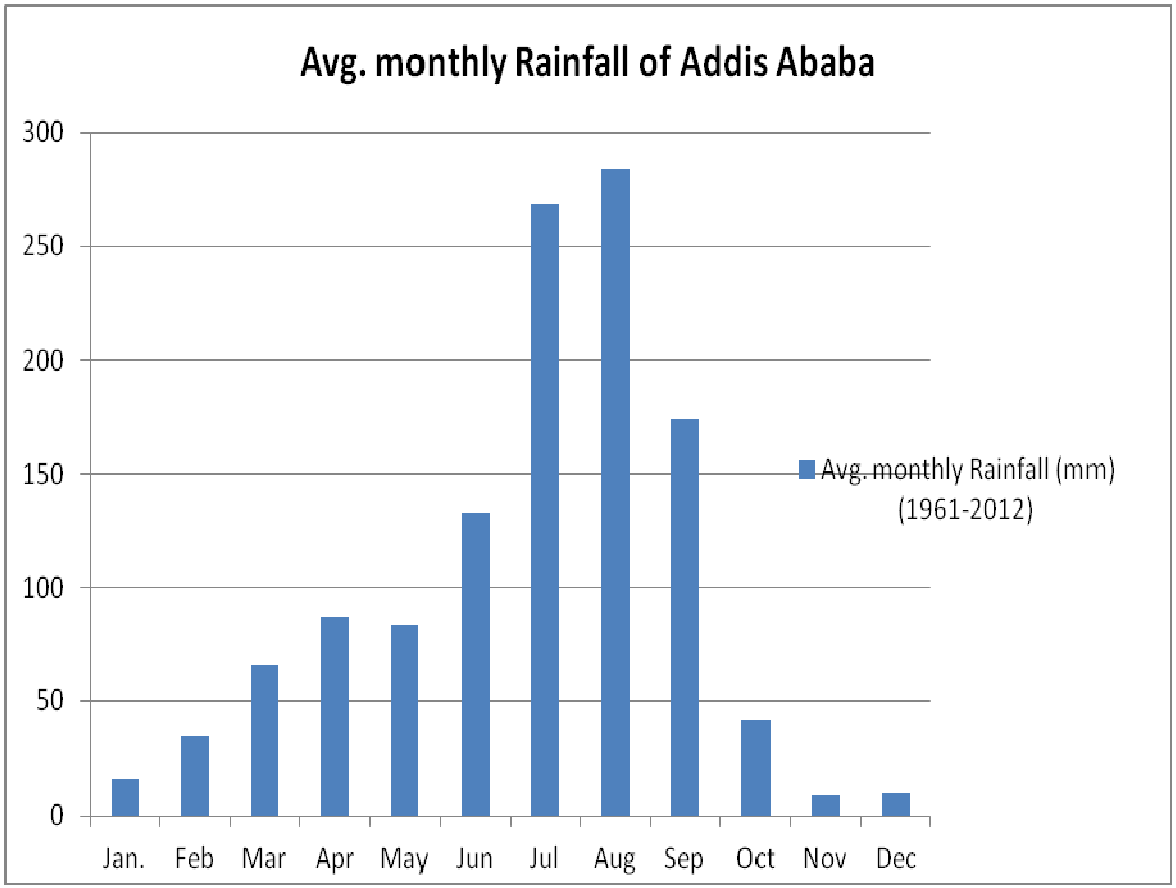
Background

- **Rivers** are often at the center of urban development, they provide water for:

  - ✓ for consumption,
  - ✓ hygiene,
  - ✓ recreation,
  - ✓ transportation,
  - ✓ irrigation, fishing and other ecological services (Cohn, 1998).

- In many urban areas, uncontrolled waste :
  - ✓ degrades surface water quality &
  - ✓ threatens human health & aquatic life.

Rainfall pattern of Addis Ababa



50-60% falls in July & August

Challenges:

- Erratic rainfall

✓River flooding

✓Flash flooding

✓overflowing of stormwater on infrastructure

✓ river water pollution

Mean annual rainfall = 1058mm (42 inch) (NMA, 2016)

Status of waste management

Wastewater management

- Sanitation facilities:
  - ✓ Flush toilet
  - ✓ Pit latrine
  - ✓ sewers
  - – Of the total population, 14.3% has no sanitation facilities (CSA, 2008)
- The overall wastewater collection coverage = 44.3% (AAWSA, 2011)
  - ✓ 7.3% by sewer lines &
  - ✓ 37% by vacuum trucks

Solid waste management

- Of the total solid waste generation:
  - ✓ unmanaged solid waste = 25% is (Nigatu et al., 2011)

Where do the unmanaged wastes go?

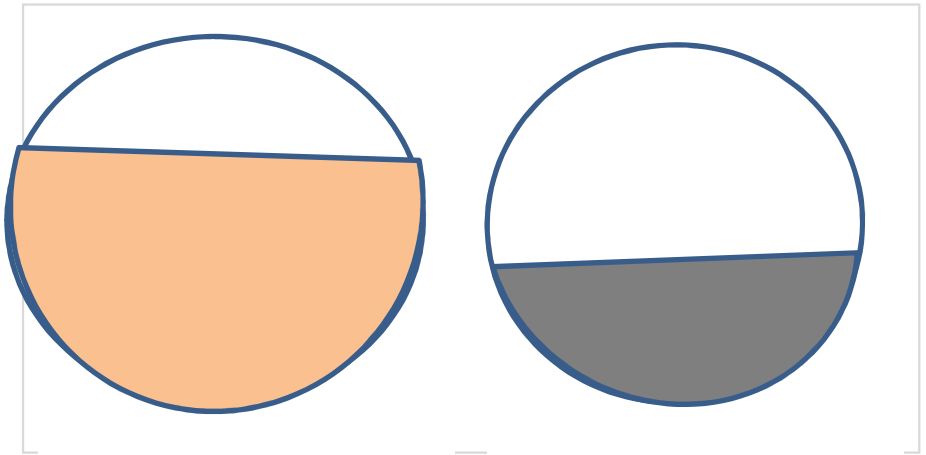
Condition of Drains & Rivers: Dry vs wet season

Condition of drains

Rainy season

Dry season

Condition of Rivers



Rainy season

Dry season

- Dry Season – Water Quality = Point Source Pollutants
- Wet Season – Water Quality = Point Source & Non-Point Source Pollutants

Research gaps/Questions

In Addis Ababa;

- What is the impact of urbanization on Rivers located in the densely, moderate and less urbanized parts of the city?

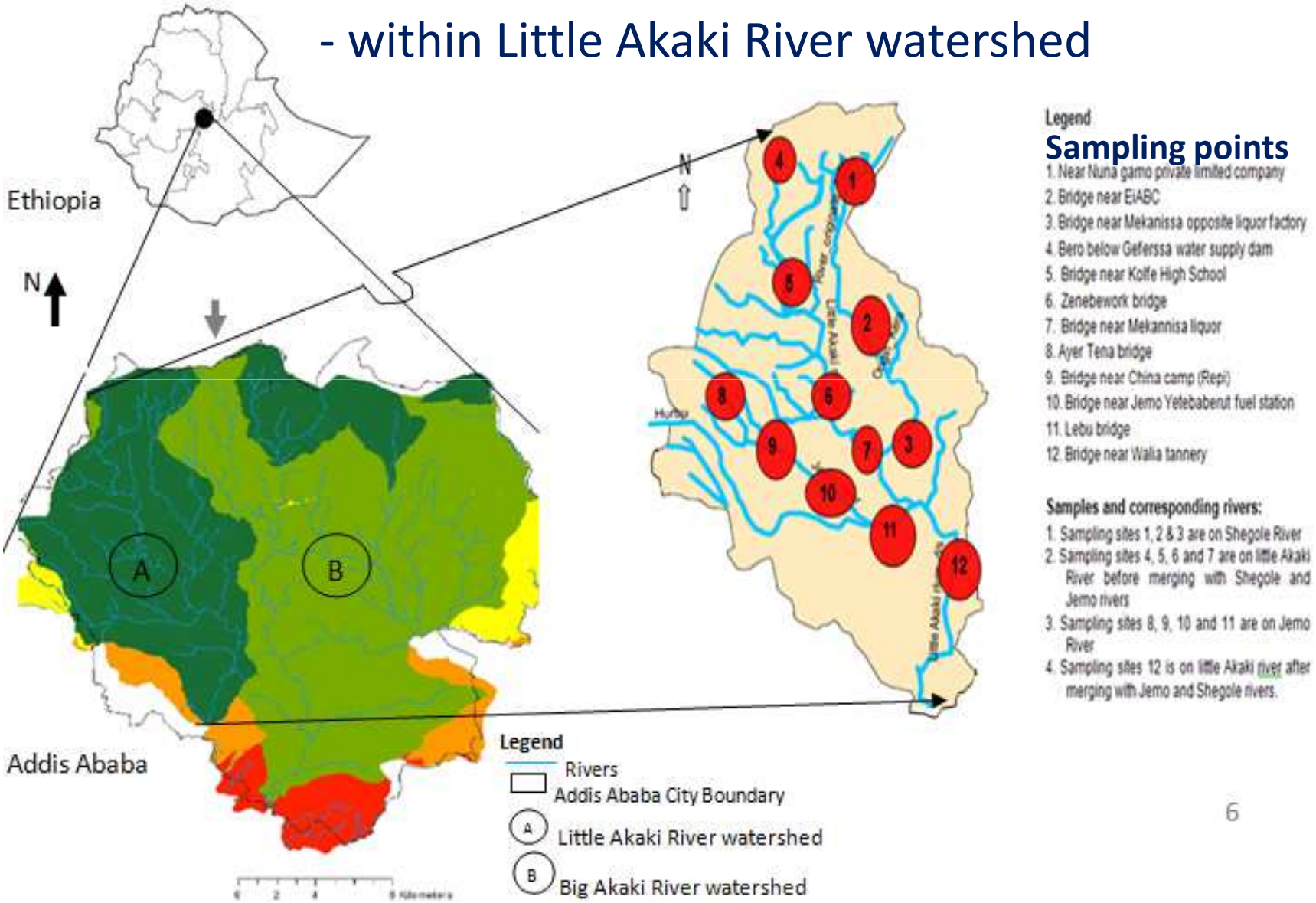
- Which is the greatest source of river water pollution? Point source (dry season conditions) or Non-Point source (wet season conditions)?

- Do the pollutant levels increase from upstream to midstream to downstream?

The study area

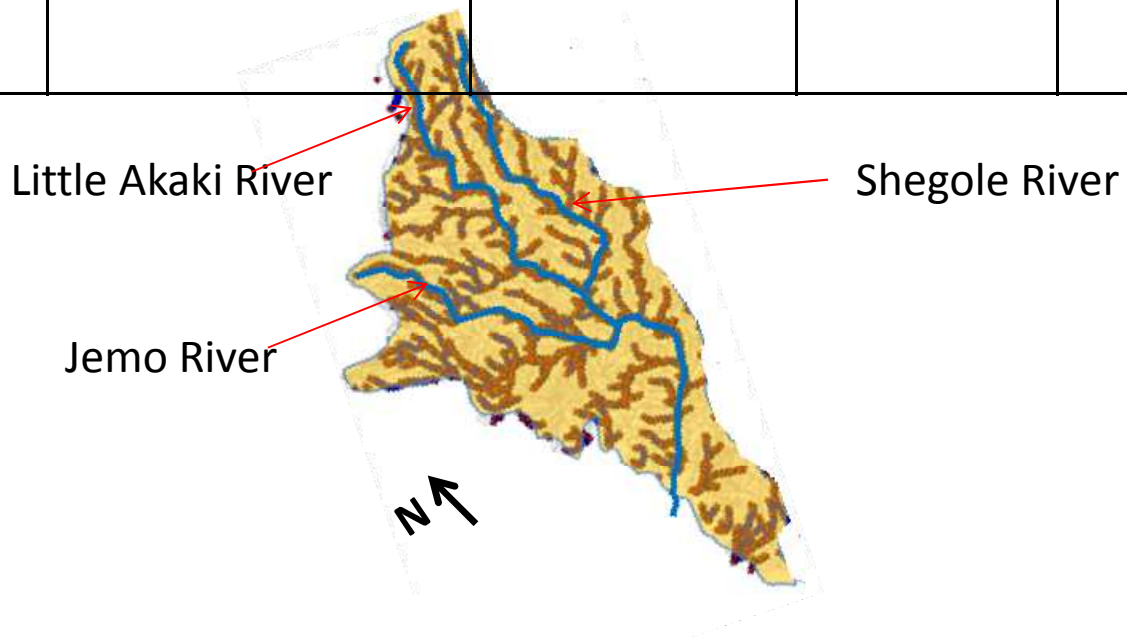
- The study was conducted in Addis Ababa:

  - within Little Akaki River watershed



River water quality parameters sampling

River	Location based on level of urbanization	Samples collected	Samples Taken	Replication	No. sampling points
Shegole	Densely urbanized	u/s, m/s & d/s	Dry & Wet	4 (2=Dry + 2=wet)	3
Little Akaki	Moderately urbanized	u/s, m/s & d/s	Dry & Wet	4 (2=Dry + 2=wet)	4
Jemo	Less urbanized	u/s, m/s & d/s	Dry & Wet	4 (2=Dry + 2=wet)	4



Statistical Analysis

- SPSS (IBM SPSS version 20, US) software employed:
  - Mean,
  - Median,
  - the 1st and 3rd quartile of the water quality parameters data were derive.

1.1 Impact of urbanization on physicochemical properties in 3-studied Rivers

		Season							
		Dry				Wet			
Ave. concentration of water quality parameters		**DO**	**EC**	**Turbidity**	**pH**	**DO**	**EC**	**Turbidity**	pH
Shegole (highly urbanized		Low	Higher	Higher	Low	High	Higher	High	Low
Little Akaki (moderate urbanized)		Higher	Low	Low	High	Higher	Low	Higher	High
Jemo (Less urbanized)		high	High	High	Higher	low	High	Low	Higher
Relative status of pollution	More polluted	Shegole	Shegole	Shegole	limit	Jemo	Shegole	L.Akaki	limit
	2nd	Jemo	Jemo	Jemo	limit	Shegol	Jemo	Sehgole	limit
	Less polluted	L.Akaki	L.Akaki	L.Akaki	limit	L.Akaki	L.Akaki	Jemo	limit

1.2 Impact of urbanization on Nutrients in 3-studied Rivers

		Season							
		Dry				Wet			
Ave. concentration of water quality parameters		**NO2-N**	**NO3-N**	**NH3-N**	**PO4-P**	**NO2-N**	**NO3-N**	**NH3-N**	**PO4-P**
Shegole (highly urbanized		Higher	Higher	High	Higher	low	low	High	High
Little Akaki (moderate urbanized)		low	Low	Low	Low	High	High	low	Low
Jemo (Less urbanized)		High	High	Higher	High	Higher	Higher	Higher	Higher
Relative status of pollution	More polluted	Shegole	Shegole	Jemo	Shegole	Jemo	Jemo	Jemo	Jemo
	2nd	Jemo	Jemo	Shegole	Shegole	Jemo	Jemo	Jemo	Jemo
	Less polluted	L.Akaki	L.Akaki	L.Akaki	L.Akaki	Shegole	Shegole	L.Akaki	L.Akaki

1.3 Impact of urbanization on Heavy metals in 3-studied Rivers

		Season							
		Dry				Wet			
Ave. concentration of water quality parameters		**Cr**	**Mn**	**Cu**	**Zn**	**Cr**	**Mn**	**Cu**	**Zn**
Shegole (highly urbanized		Higher	High	Low	Higher	Higher	High	Low	Higher
Little Akaki (moderate urbanized)		Low	Low	Higher	Low	Low	Low	High	Low
Jemo (Less urbanized)		High	Higher	High	High	High	Higher	Higher	High
Relative status of pollution	More polluted	Shegole	Jemo	L.Akaki	Shegole	Shegole	Jemo	Jemo	Shegole
	2nd	Jemo	Shegole	Jemo	Jemo	Jemo	Shegole	L.Akaki	Jemo
	Less polluted	L.Akaki	L.Akaki	Shegole	L.Akaki	L.Akaki	L.Akaki	Shegole	L.Akaki

2. Impact of season on: Physicochemical, Nutrients & Heavy metals

Parameter	season	
	Dry season	Wet season
	mean	mean
DO (mg/l)	-	High concentration (+)
EC (μs/cm)	High concentration	-
Turbidity (NTU)	-	High concentration
pH	-	More pH
NO2-N (mg/l)	-	High concentration
NO3-N (mg/l)	-	High concentration
NH3-N (mg/l)	High concentration	-
PO4-P (mg/l)	High concentration	-
Cr (mg/l)	-	High concentration
Mn (mg/l)	High concentration	-
Cu (mg/l)	High concentration	-
Zn (mg/l)	High concentration	-

Findings

Parameter/location	Dry	Wet
DO (mg/l): u/s	**High concentration (+)**	**High concentration (+)**
m/s	second	Second
d/s	least	Least
EC (µs/cm): u/s	**High concentration**	Second
m/s	Least	Least
d/s	Second	**High concentration**
Turbidity (NTU): u/s	**High concentration**	Second
m/s	Least	**High concentration**
d/s	Second	Least
pH : u/s	least	Least
m/s	Second	Second
d/s	**High pH**	**High pH**
NO2-N (mg/l): u/s	Second	Least
m/s	Least	second
d/s	**High concentration**	**High concentration**
NO3-N (mg/l): u/s	Least	least
m/s	Second	Second
d/s	**High concentration**	**High concentration**
NH3-N (mg/l): u/s	Least	**High concentration**
m/s	**High concentration**	second
d/s	Second	Least
PO4-P (mg/l): u/s	Least	Least
m/s	Second	Second
d/s	**High concentration**	**High concentration**
Cr (mg/l): u/s	Second	**High concentration**
m/s	Least	Least
d/s	**High concentration**	Second
Mn (mg/l): u/s	Second	**High concentration**
m/s	**High concentration**	Second
d/s	Least	Second
Cu (mg/l): u/s	Least	**High concentration**
m/s	Second	Second
d/s	**High concentration**	Least
Zn (mg/l): u/s	**High concentration**	**High concentration**
m/s	Least	Least
d/s	Second	Second

Conclusion:

- ✓ The average concentration of all the measured parameters were inconsistent from u/s to m/s to d/s:
  - it should have been increased from u/s to d/s due to accumulation, but in the present study, not:
    - Reason: Adjacent & polluting land uses

- ✓ In both the dry & wet seasons, pollution was higher than the recommended levels, except:
  - pH within the recommended level (both seasons) &
  - DO (only in the wet season)

Implications

- The impact of urbanization on rivers located in the densely, moderate and less urbanized parts of the city is not known?

The level of urbanization does not explain water pollution levels in Addis Ababa. For planning, the adjacent land uses are more important than density.

- Which is the greatest source of river water pollution? Point source (dry season conditions) or Non-Point source (wet season conditions)?

Point sources are most important in degrading river water quality – This is opposite to conditions in developed countries where Non-Point (stormwater) is the major polluter.

- Do the pollutant levels increase from upstream to midstream to downstream?

This is inconsistent with expectations – The adjacent land uses are more important and buffers are needed.

Acknowledgment

Prof. Brook Lemma, Addis Ababa University

Prof. Marina Bergen Jensen, Copenhagen University

Dr.Ing. Geremew Sahilu, Addis Ababa University

Prof. Larissa Larsen, University of Michigan

Dr. Kumelachew Yeshitela

We would also acknowledge DANIDA for the financial support.