Assessment of the Tanzanian Biogas Sector:

First Empirical Results using the Appropriate Energy Model

Bob Jan Schoot Uiterkamp

August 2011

Universiteit Utrecht

SNV Netherlands Development Organisation

Assessment of the Tanzanian Biogas Sector:

First Empirical Results using the Appropriate Energy Model

Author	R.J.H. Schoot Uiterkamp
Student number	3645908
E-mail	rjh.schootuiterkamp@gmail.com
University	Utrecht University
Faculty	Faculty of Geosciences
Specialization	MSc International Development Studies
Supervisors Utrecht University	Dr. H. Huisman
	Dr. P.H.C.M. van Lindert
Institute	SNV Netherlands Development Organisation Tanzania, Northern Portfolio
Supervisor SNV	MPhil. T. Noorbhai
Place and date	Utrecht, August 2011

Universiteit Utrecht

SNV Netherlands Development Organisation

EXECUTIVE SUMMARY

Access to modern energy is vital to achieve sustainable development and to reduce poverty. Nevertheless, only 10-24 per cent of Sub-Saharan African (hereafter: African) population has access to electricity, with far lower access rates in rural areas. The electricity grid in African countries is limited expanded to rural areas since African rural human settlements are sparsely populated, which makes expansion of the central electricity grid to rural areas commercially unfeasible. Even in urban areas with access to the electricity grid and in rural areas where the electricity grid is expanded; only the wealthiest residents can afford connections. For these reasons, most Africans still rely on low-quality biomass energy sources as firewood and charcoal to meet their energy needs. The overreliance on biomass for cooking results in 400.000 deaths annually due to indoor air pollution caused by smoke and results in environmental degradation.

Consequently, small-scale decentralised energy sources are presented to improve access to ‘appropriate’ energy, which are beneficial from human health and environmental perspectives. Moreover, the installation of small-scale energy sources is presented as income generating activity for the poor as well. Anaerobic digestion of biomass, popularly referred to as biogas, is one such appropriate energy technology for domestic usage, which receives renewed attention in Africa. Tanzania is one of the countries where since a year of five, donor-led, initiatives take place to disseminate both rural and urban domestic biogas applications. Despite it, limited knowledge exists regarding the determinants for the formation of appropriate energy clusters to foster structural dissemination of the technology. Therefore, this study presents a model to measure the degree of appropriate energy cluster formation, which sensitises for ‘institutional, enterprise and contextual’ dimensions. The model is applied to assess the degree of biogas cluster formation in rural Northern Tanzania and in Tanzania’s urban economic capital, Dar es Salaam, by using quantitative and qualitative methods of analysis.

The results showed that the institutional dimension is characterised with limited national-, and local-government support for energy business development, while private-, and (governmental-) non-governmental organisations provide business development services. At the enterprise dimension, a membership based energy association is developed and two foreign private-sector companies entered the market, yet local biogas business development is almost completely absent. Climatic-, geographical-, economic-, cultural-, and type of employment characteristics are noted as important as contextual dimensions. Higher potential for cluster formation is noticed in urban agglomerations.

This study find presence of integrated rural energy centres; the potential to target groups of customers via dairy cooperatives; word-of-mouth promotion; access to finance; presence of membership-based energy association; higher competition among biogas suppliers and creative biogas lease constructions facilitative to biogas cluster formation. On the contrary, lack of governmental appropriate energy vision; low support and limited transparency for business development and lack of national quality certification are institutional constraints to biogas cluster formation. In addition, risk avoidant behaviour and limited expertise of biogas masons hamper local biogas business development. In addition, this study identifies high investment costs, higher costs of transportation of input materials in rural areas and seasonal income generation of households, which impedes taking biogas loans as economic constraints for biogas adoption. Contextual dimensions, which negatively affect biogas sector development, are first erratic precipitation in combination with unaffordable mitigation tools, which limits the functionality of biogas installations. Second, high installation-and quality control costs per customer due to sparsely populated areas and third, misfit between pastoralist way of living of a substantial share of potential customers and current cooking habits of certain ethnic groups, which reject the use of biogas.

Keywords: Appropriate energy, clusters, economic geography, Tanzania, biogas

PREFACE

The writing of this master thesis is the last assignment to finalise the Master International Development Studies at Utrecht University. It also forms the last stage of my six year student-life. As an 18-year old who was raised by caring parents in the East of the Netherlands, I started my student life in 2005 in Groningen, as a boy still. Being mainly focused on having fun with friends in the many bars Groningen is rich and at the student rowing club, the world was one, and a great place to be at. Since a student-life also requires a field of study, I decided to study Business Studies. I was not that much passionate of it from the beginning, so I started searching for alternatives to trigger myself. I found many: numerous committees, part-time jobs and a year of full-time rowing. In 2007, I discovered that the world consisted of more than Groningen and the Netherlands as the centre of universe, when I studied for six months as Erasmus exchange student in Sweden. Although my world was enlarged with influences from other cultures, languages and traditions, the world at large as a great place to be at was still prevailing in my world vision.

Then, in 2008, I fell down to the earthly realities the world is rich, or actually 'is poor'. During a business research project in India, vague terms as poverty, desperation, hope, slums and pollution, which I knew from television, all at once jumped to the front of my thinking: 'why?' 'how?' but foremost: 'how to overcome?' I decided to take a side step from my Master International Business and Management and dedicatedly study 'development issues' for six months; I had to know. I became convinced that capacitating small producer enterprises to improve the quality of products and to increase their productivity would be a good first step; we live in capitalist, money driven, societies after all. With the support of my thesis supervisor in Groningen, Bartjan Pennink, I got the opportunity to travel to Indonesia to 'go and look for myself' whether capacity development interventions indeed resulted in more jobs, higher incomes and improved standards of life.

The fact that the thesis in front of you, exists, means two things. First, I found sufficient leads in Indonesia to believe that capacity development interventions can work when implemented within supportive institutional frameworks to start a Master in International Development Studies in Utrecht. Second, I had to broaden my horizon to the African continent to be honest to myself when saying that I've put all my efforts in discovering paths which might bring the world a little closer to a good place to be at…for more of us.

“*Gratitude is the memory of the heart*”

-Jean Baptiste Massieu-

At this place I would like to express my gratitude to all those who made this thesis possible. First, my gratitude goes to Henk Huisman, my supervisor from Utrecht University who initiated the project, granted me the trust to fulfil this assignment and guided me through the internship project and the final structuring of the thesis. In addition, I would like to thank Paul van Lindert who took the time to read this thesis as second supervisor. Third, I would like to thank Tayeb Noorbhai, who supervised the internship period in Arusha. Your support was invaluable, your dedication inspiring and we share the ambitious, yet complicated search to do things right, but foremost to do the right things. Furthermore, I am grateful to the friendly SNV colleagues in Arusha for showing interest in our work and life’s and providing an opening to the Tanzanian culture(s) and Kiswahili. Then, I owe a lot to all those who participated freely to the data collection process, without your contribution this study would not be as it is now. Furthermore, it made the internship period another eye-opener in my life.

It was great to discover Tanzania together with a group of open- and positive- minded students from Utrecht University. Anjelle, Frederieke, Ilse, Jes, Kleoniki and Marcy, thanks for the good time we had together and team Mwanza: thanks for hosting me twice; it was wonderful! A great smile pops up when I think of Joost Meijer. We started the internship as strangers for each other and suddenly we shared an apartment, colleagues and research project. The efforts you put in our study, in combination with your intellect, humour, the open discussions we had and not to forget the cup of tea you prepared every morning, will always be in my memory when I think about Tanzania and this study. Asante kaka!

Finally, I would like to thank my friends and family. Johan and Tom, your spontaneous two-week visit was much appreciated: it is true; happiness is only real when shared. Also, I would like to thank my parents and sister, Jan, Therese and Ann. Mom and dad, you provided me with a solid base for personal development, support and trust, always. For long, I will remember travelling ‘the local way’ together in Tanzania. After all, Christien, you are always next to me, we share so much, you’re (most of the time) open for my nightly reflections on life, and you got me through these final thesis-steps, again, asante kabisa!

Bob Jan Schoot Uiterkamp

Utrecht, August 2011

TABLE OF CONTENTS

GLOSSARY OF ACRONYMS

ABPP	Africa Biogas Partnership Programme
ARET	Appropriate Renewable Energy Technologies
BDS	Business Development Services
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology Tanzania
CERC	Community Energy Resource Centre
FIRR	Financial Internal Rate of Return
GOT	Government of Tanzania
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
IAP	Indoor Air Pollution
IMF	International Monetary Fund
IREU	Integrated Rural Energy Utility
LED	Local Economic Development
LGA	Local Government Authorities
LMICs	Lower Middle Income Countries
MFI	Micro-finance Institution
NGO	Non- Governmental Organization
NSGRP II	National Strategy for Growth and Reduction of Poverty II
PRSP	Poverty Reduction Strategy Paper
REA	Rural Energy Agency
REF	Rural Energy Fund
SACCOS	Savings and Credit Cooperative Societies
SAPs	Structural Adjustment Programmes
SIDO	Small Industries Development Organization Tanzania
SME	Small and Medium Enterprises
SNV	Netherlands Development Organization
TANESCO	Tanzania Electricity Supply Company
TASEA	Tanzania Solar Energy Association
TaTEDO	Tanzania Traditional Energy Development and Environment Organization (or: Centre for Sustainable Modern Energy Initiatives)
TDBP	Tanzania Domestic Biogas Program

TZS	Tanzanian Shilling
VICOBA	Village Community Bank
WB	The World Bank

LIST OF FIGURES

LIST OF MAPS

LIST OF TABLES

August ’11 exchange rates: 1 Euro = TZS 2.233 / 1 USD = TZS 1.579

1. ENERGY FROM WASTE?

Always when someone asked where my study in Tanzania was about, I answered "Dung". Although dung is not exactly a subject discussed a lot in day-to-day conversations, this answer always provoked discussion about the potential to generate energy from biomass and the socio-economic improvements it might deliver, especially when developing countries are regarded. The following pages describe the current energy situation of developing countries together with the energy needs unmet and solutions proposed in development literature and by development practitioners. Then, as derived from gaps identified, the objectives of this study are presented. The initiative to conduct this study is the outcome of cooperation between the renewable energy team of SNV Tanzania and Utrecht University in the Netherlands. Profound literature analysis and data collected during a three-month research internship hosted by SNV in Arusha form the basis of this study.

1.1 The Energy Situation in Developing Countries

It is widely accepted that access to modern energy sources is vital for sustainable development and poverty reduction (Kiplagat, Wang and Li, 2011; Reddy, 2008). Despite the important role of access to modern energy sources, it proves to be problematic to get energy to the majority of population in developing countries since national electricity grids are limited expanded to rural areas and access to electricity is too expensive for poor populations. The limited expansion of electricity grids to rural areas is explained by limited commercial viability due to the low population density and decentralised nature of human settlements (Hiremath, Shikba and Ravindranath, 2007) as well as limited technical-, and managerial capabilities to manage large-scale energy projects (Karekezi, 2002; Mbuligwe and Kassenga, 2004). Consequently, the vast majority of populations still depend on traditional wood fuels for their energy needs (Barry, Steyn and Brent, 2011). The limited access and affordability of modern energy in developing countries receives significant attention at present and is adequate expressed by the following UNDP (2011:1) citation: "*None of the Millennium Development Goals (MDGs*[1]*) can be met without major improvement in the quality and quantity of energy services in developing countries*". As a result, numerous initiatives exist to

[1] Resolution adopted by the General Assembly of the United Nations in 2000 which agrees to strive to achieve eight goals by 2015. The goals include the eradication of extreme hunger and poverty, achieve universal primary education, promote gender equality and women empowerment, reduce child mortality, improve maternal health, combat HIV/aids, malaria and other diseases, ensure environmental sustainability and develop a global partnership for development (Rigg, 2008: 30-32).

address the energy situation in developing countries as will be presented in the next section.

1.2 What a Waste and What a Potential

To address the energy needs of rural areas and the urban poor, small-scale, decentralised energy provisions, like solar, wind and biomass, which sensitize for local available resources and regional demand, are presented as more appropriate to address energy needs in developing countries (Barry et al., 2011; Hiremath et al., 2007). The anaerobic digestion of biomass (hereafter: biogas) is one of these small-scale energy initiatives. If proper conducted the digestion process of agricultural- and non-agricultural wastes can result in the provision of gas for cooking and even for lighting. The remainder of this study focuses on biogas as proposed decentralised, small-scale energy provision.

Biogas is considered appropriate since it addresses local energy needs and at the same time, it is presented as a solution to increasing waste burdens in developing countries. Increased solid waste generation and improper management thereof in developing countries are a burden to human health and the environment[2] (Cofie et al., 2009; Misra and Pandey, 2005; Sépulveda et al., 2010). Nevertheless, since the composition of wastes in developing consists predominantly[3] of biomass, e.g. organic, biodegradable material; most wastes are considered suitable as inputs for biogas production (Weiland, 2010). The adoption of biogas technology reduces the need for traditional energy sources as wood, charcoal and fossil fuels and thereby reduces environmental degradation. In addition, the residue is an improved agricultural fertiliser which can substitute the use of chemical fertilisers (Bogner et al., 2008; Cofie et al., 2009; Mshandete and Parawira, 2009; Weiland, 2010). Meanwhile, biogas technology has social considerations: it reduces indoor air pollution from burning of biomass for cooking and consequently results in lower child mortality (Fullerton, Brucec and Gordona, 2008) and reduces workload to collect firewood, often performed by women (Mahat, 2003). Moreover, biogas is desirable from an economic point of view: the installation of bio digesters provides the ability to create jobs for growing populations in developing countries (Kiplagat et al., 2011). After all, the adoption of biogas technology neutralises – and can even offset – methane emissions associated with solid wastes and can be registered as small-scale 'Clean

[2] Local government authorities (LGAs) are in charge of managing wastes (Friedrich and Trois, 2011); yet often lack the technical knowledge, institutional competence and funding base to meet responsibilities (Satterthwaite, 2008).

[3] 50 to 90 per cent of wastes in developing countries is biodegradable (Allison et al., 1996; Asomani-Boateng and Haigth, 1999).

Development Mechanisms' (CDM)[4] (Barton, Issaias and Stentiford, 2008).

Biogas is applicable to address energy needs in both urban and rural areas (Xinyu, 2010). Biogas production from non-agricultural wastes is considered viable in urban areas of developing countries, due to growing waste volumes and content of wastes in urban areas. Non-agricultural wastes are less plentiful in rural areas, yet substituted for by agricultural wastes since in many developing countries, large numbers of ruminant livestock, like cattle, goats and sheep are kept in rural areas, which provide manure for rural biogas application (Kassenga, 1997; Mshandete and Parawira, 2009; Mwakaje, 2008; Shafi, 2006).

1.3 Earlier Experiences with Biogas in Tanzania

The potential of biogas to address energy needs in developing countries is addressed in the previous section. Besides the theoretical considerations, biogas has a long history of being disseminated in practice as well. Especially Asian countries have a long history with small-scale biogas, while biogas has been introduced to a limited extent to some sub-Saharan African (hereafter: African) countries as well. The United Republic of Tanzania (hereafter: Tanzania) has already a long history with biogas (Mwakaje, 2008). Biogas was predominantly introduced in the 1980s and 1990s via a partnership between the German GTZ and the Tanzanian parastatal CAMARTEC, yet the partnership failed to establish a structural biogas sector and since the 1990s the large-scale dissemination of biogas ended (Marree and Nijboer, 2007; Sasse, Kellner and Kimaro, 1991[5]). However, recently, small-scale biogas technologies in Tanzanian received renewed attention. The potential of biogas has been subject of study in two feasibility studies, one performed by students from the Utrecht University (Marree and Nijboer, 2007) and another by GTZ (2007). In both studies, the feasibility of biogas in Tanzania on household level was assessed based on experiences, climatic characteristics and household characteristics. In general, the high costs are seen as a major hurdle. In addition, Marree and Nijboer (2007:159) and the SNV's 'programme implementation document' (PID), acknowledge that limited water availability forms a hindrance to the performance of bio

[4] Article 12 of Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC). Projects that reduce GHG emissions can allocate the carbon reductions to companies in developed countries (Barton et al., 2008:691). Example biogas Nepal: Successfully registered small-scale biogas plant which operates on the basis of animal dung. Since the digester substitutes for kerosene and unsustainable firewood use, it was assessed appropriate to offset GHG emissions (Barton et al., 2008: 697).

[5] Please refer to Sasse et al., (1991) and Marree and Nijboer (2007) for a comprehensive overview of the history of biogas in Tanzania.

digesters (SNV, 2009). The same studies state that feeding problems associated with water scarcity can be addressed by water harvesting systems and efficient collection of urine of cattle by the installation of improved stables. After all, in 2009, an ambitious programme to develop the Tanzanian rural biogas sector was started through the heavily donor supported Tanzania Domestic Biogas Programme (TDBP).

1.4 Current Biogas Interventions in Tanzania

1.4.1 Rural

Dutch NGOs Hivos and SNV joined hands to foster the development of a commercially viable biogas sector, financially supported by DGIS in the Africa Biogas Partnership Programme (ABPP), which was launched in six African countries in December 2008. In Tanzania, the programme is coordinated by TDBP, which is part of CAMARTEC. The goal of the programme is to improve the livelihoods and quality of life of rural farmers in Tanzania through exploiting the market and non-market benefits of domestic biogas. The ambition is to support the installation of 12.000 domestic biogas installations (SNV, 2009). By the end of 2010, a total number of 1000 domestic, rural bio digesters had been installed by the programme and at the time of writing; the total number surpassed 1400 installations (The Citizen, 2011). Currently TDBP develops a biogas plant model for pastoralists, employing the manure that can be collected when cattle is kept at one place at night.

1.4.2 Urban

The Indian organisation Appropriate Rural Technology Institute (ARTI) developed in 2003 a small-scale bio digester, which produces gas based upon the input of organic non-agricultural wastes such as food wastes and is thereby suitable for urban use par excellence. Around 2500 of the ARTI bio digesters have been sold in India and the bio digester is introduced in Tanzania in 2007 as well (Müller, 2007). Early 2011, 60 urban bio digesters had been sold, including several institutional digesters for schools and hospitals (ARTI, 2011).

1.5 Gaps in Literature

To recapitulate, the previous sections showed the theoretical potential of biogas to address energy needs and the practical application of the technology in Tanzania. It is important that to actually deliver the benefits associated with biogas technologies, Tanzanian rural and urban population switch from traditional energy sources and adopt biogas technologies. Hereby, Kiplagat et al. (2011:2971), Mwakaje (2008:2250) and Karekezi (2002: 1066) argue that strategies to develop decentralised small-scale biomass energy systems should deliver jobs to generate income for the rural and urban poor.

Despite increased recognition of the potential of biogas in developing countries in general and in Tanzania in particular and a number of donor and/or government led initiatives to provide biogas installations (Friedrich and Trois, 2011; Mshandete and Parawira, 2009; SNV, 2009); the facilitators and barriers to structural disseminate the biogas technology in African societies are largely ignored until present. Earlier studies focused primarily on the household level potential of biogas. Although neglected, there is a clear need to identify facilitators and barriers, which affect the dissemination of biogas in African countries. Energy transitions in rural areas are incremental processes, whereby the dissemination of technologies takes place via gradual absorption into production systems like small firms, large enterprises or rural households (Malecki, 1997). The absorption of new technologies in production systems takes place via 'cluster formation', e.g. local multi-stakeholder and multi-sector partnerships, where public-, private-, and non-governmental actors cooperate and benefit from mutual learning (Breschi and Malerba, 2011; Helmsing, 2001; Pike, Rodríguez-Pose and Tomaney, 2006). Thus, the dissemination of biogas depends on the ability to create local multi-sector partnerships around the technology. Nevertheless, Breschi and Malerba (2001: 820) argue that there is limited knowledge how 'clusters' emerge, since most literature focuses on existing, well established clusters like Silicon Valley and therefore urge for more analytical and empirical efforts to understand the conditions and the process leading to the establishment of technology based clusters. Some conditions, which should be taken into consideration to assess whether the required technological capabilities will be developed in a region to absorb new technologies, are local economic, social, political and cultural factors (Malecki, 1997).

Therefore, the emphasis in the present study is to assess the conditions in Tanzania, which are of relevance to assess the potential for biogas cluster formation. In addition, to our knowledge, no single research has ever constructed a model, which incorporates required public-, and non-governmental sector actions, identifies preferred private sector dynamics and characteristics and indicates the demand potential for appropriate renewable energy technologies, through which the potential to create appropriate energy clusters in African societies can be understood and examined.

1.6 Objectives

Hence, derived from the previous section, the aim of this study is fourfold. First, we assess the present-day conditions to generate energy from biomass in Tanzania. Secondly, we assess the current state of the biogas sector in Tanzania by means of a case study. Third, in order to assess the biogas sector in Tanzania, we propose an 'Appropriate Energy Model' (AEM), which is constructed based upon an existing sector development framework, adjusted for the criteria identified in literature relevant for structural energy dissemination in African societies. Fourth, based upon the biogas sector assessment in Tanzania, future directions for biogas sector formation will be presented.

Tanzania is analysed in this contribution to address the dissemination of biogas technology in African Lower Middle Income Countries[6] (LMICs). Tanzania is characterised as predominantly rural, agricultural society, with abundant biomass resources (Mshandete and Parawira, 2009). Tanzania's GDP per capita is USD 1400[7] (CIA The World Fact book, 2011) and the country is eligible to receive aid and loans without accelerating industrialisation (Szirmai, 2005:20). Need for alternative waste management and energy provision exists due to population growth (UN Desa, 2007), improper solid waste management (Henry, Yongsheng and Jun, 2006; Manga, Forton and Read, 2008), and rising energy consumption per capita (IEA, 2007). Energy needs are primarily fulfilled by traditional energy sources (Mwakaje, 2008), which form a risk to the environment and human health (Ezzati et al., 2002; Fullerton et al., 2008). Moreover, prior studies (GTZ, 2007; Marree and Nijboer, 2007) assessed the dissemination of biogas in Tanzania as feasible. Thereby, the following two-fold research question can be asked: 1a. *"What are the conditions to generate energy from biomass in Tanzania?"* 1b. *"What strategies fit best for biogas cluster formation in Tanzania?"*

Since lack of access to appropriate energy sources is the most urgent in rural areas (Hiremath et al., 2007), the scope of this research is focused to investigate the conditions for biogas sector development in four rural regions in Northern Tanzania, e.g. Manyara, Arusha,

[6] Lower Middle Income Countries in terms of GDP. GDP per capita (purchasing power parity) between USD 755 -2995 (Szirmai, 2005:20–21).
[7] When corrected for purchasing power parity. The uncorrected GDP per capita is €308 (GoT, 2011)

Kilimanjaro and Tanga. Then, since sustainable waste management is the most urgent ecological action in ‘megacities’ (Hoornweg and Laura, 1999; Troschinetz and Mihelcic, 2009), this study includes the largest city and economic capital of Tanzania, Dar es Salaam. Besides its size, the composition of wastes in Dar es Salaam is suitable for biogas production since 67 per cent of total solid waste generated is biodegradable (Mbuligwe and Kassenga, 2004).

1.7 Research Structure

This paper is structured as follows: the theoretical framework in chapter two. Herein, favourable conditions to generate energy from biomass are introduced. The theoretical framework further reviews the current literature in the field of technology cluster formation. Then, chapter three will address the appropriateness of biogas in Africa in general and in Tanzania in specific, followed by assumptions regarding biogas dissemination in Tanzania. Subsequently, chapter four proceeds with the methodology of the study. In chapter five, the findings of the case study will be presented followed by analysis and discussion in chapter six. After all, chapter seven will provide the conclusion, which includes limitations and areas for further study.

2. THEORETICAL FRAMEWORK

Based upon the work of influential scholars in the field of sustainable development, first definitions of appropriate renewable energy technologies and the required input materials and conditions to produce biogas are presented in section 2.1. Subsequently, since sustainable development receives significant attention at present, section 2.2 presents in short the role of wastes and the use of traditional energy sources in developing countries in relation to greenhouse gas emissions (GHG). Then, section 2.2 identifies the role biogas solutions are granted as ecological sound mitigation strategy. Hereafter, section 2.3 and 2.4 present earlier economic development strategies and current sector development strategies respectively. Finally, by means of an assessment of current literature on appropriate energy cluster formation, the input variables of the AEM are identified in sections 2.5 up to and including 2.8.

2.1 What is 'Appropriate Energy'?

Energy can be classified as commercial and non-commercial. Commercial energy sources include coal, oil and can be traded in the market. On the contrary, non-commercial energy sources such as fuel wood, dung and agricultural waste, are primarily not traded in the market (with the exception of fuel wood) in developing countries (Reddy, 2008: 318). Hereby, the generation of energy from agricultural and non-agricultural wastes is classified as non-commercial 'appropriate renewable energy technology' (ARET), which refers to energy technologies that are small-scale, locally controlled, energy efficient and centred on people, labour utilization and the environment (Akubue, 2000). ARETs can be installed near the end-user, which is economic viable due to lower distribution costs (Karekezi, 2002: 1065) and, as such, ARETs intend to sensitise for the characteristics of households and the environment.

2.1.1 Are all Wastes Equally Suitable as Inputs?

The term anaerobic digestion refers to a complicated process where agricultural wastes, agricultural raw materials or non-agricultural wastes are digested and deliver combustible biogas, e.g. methane formation[8]. All types of biomass can be used for biogas production, if they contain carbohydrates, proteins, fats, cellulose and hemicelluloses as main

[8] Please refer to Weiland (2010:850-852) for an examination of the biochemical process.

components, which include energy crops and residues, grasses, leaves, manure, fruit, vegetables and algae (Weiland, 2010). Materials are to different extends biodegradable and thereby to varying degrees applicable to produce biogas. For instance, food wastes and paper have the highest biodegradability; textile and wood which are moderate biodegradable, whereas sludge and leather are limited biodegradable, while plastic and rubber are almost not biodegradable (Bogner and Matthews, 2003). Jeon et al. (2007) find similar results, they find that food wastes and paper account for 70 per cent of biodegradable waste, textile and wood for 50 per cent, sludge and leather 25-30 for per cent and plastic and rubber only for 10 per cent. The different biomass input sources deliver varying gas yields. Of relevance for the present study are the gas yields of cow and pig manure and food residues, which are 25-30 m^3 and 240 m^3 per 1000 kilograms fresh input mass respectively (Weiland, 2010: 853). From this, it is derived that the yields of food residues are considerable higher as compared to agricultural manure wastes.

2.1.2 Optimal Yields: The Role of Climate and Management

Besides the distinctions in input materials, management- and climate conditions matter as well. Management factors that foster methane production are to avoid contact of biomass with oxygen, add sufficient water, stabilise ph conditions and the addition of nutrients when food residues are concerned (EIIP, 1999: chapter 2.2). If during the anaerobic digestion process input materials have contact with oxygen, there is no potential for methane production. The availability of water has three benefits; first, it promotes an oxygen free environment and accelerates the process of anaerobic decomposition. Secondly, water is required to stabilise ph values. Methane formation takes place under stable ph values of 6.6 - 8.0 (EIIP, 1999) or 6.5-8.5 (Weiland, 2010). Third, moist conditions increase the potential for methane production (EIIP, 1999), while nutrients are required for the growth and survival of specific microorganisms (Weiland, 2010:851). For the anaerobic digestion of manure, it is not necessary to add nutrients since manure contains sufficient nutrients to sustain methane formation (EIIP, 1999). When waste or energy crops are considered, nutrients should be added for the formation of methane. Hereby, the addition of manure in the digester reduces the lack of micronutrients (Weiland, 2010:852). Climate factors that foster methane production are high temperatures and rainfall and/or humidity (EIIP, 1999). Chawla (1986) argues that temperature is one of the most important factors that affect the growth of bacteria responsible for methane formation. The rate of methane formation generally increases with rising temperature (EIIP, 1999); temperatures around 35[9] degrees Celsius are considered facilitative to methane formation (Weiland, 2010:856). The important role of water availability in the process of methane formation is addressed before. Therefore, rainfall and humidity are required to produce methane via anaerobic digestion (EIIP, 1999).

Hence, the climatic conditions should be facilitative to biogas production and need to be known to assess the potential performance of biogas technologies in a given geographical context. Applied to water input requirements of biogas digesters, the following applies: the smallest rural, manure operating digesters require a daily input of 25 litres of water under minimal feeding (SNV, 2009); while urban, non-agricultural waste operated biogas installations require 2-5 litres of water daily (ARTI, 2011). Besides the climatic conditions, the actual feeding of digesters requires sufficient agricultural and/or non-agricultural wastes. For rural application, the dung of 2-3 cows or the equivalent from other feedstock, or human excreta is required to feed a biogas digester (Karekezi, 2002), one litre of water for one kilogramme of dung (SNV, 2009); while urban digesters require a minimum input of 2-5 kg of waste daily (Voegeli et al., 2009).

The following sections introduce the option to reduce GHG emissions caused by wastes and traditional energy provision by adopting small-scale biogas provisions.

2.2 Biogas: a Win-Win Solution?

2.2.1 Waste and Methane Emissions

The reduction of global greenhouse gas (GHG) emissions receives significant scientific attention at present (Cox et al., 2000; Parmesan and Yohe, 2003). It has been stated that the burning of fossil fuels and deforestation by burning are the most significant human contributions which causes increases in the main GHG, carbon dioxide (CO_2) (McGregor, 2008: 285). Another GHG that can cause global warming is methane (CH_4); although less-studied, methane emissions contribute significant to total GHG emissions (Lashof and Ahuja, 1990), estimated to be 14 per cent in 2004 (Bogner et al., 2008). More than 60 percent of atmospheric methane comes from human activities, which include rice agriculture, fossil fuel production and consumption, natural gas usage, ruminant livestock keeping and biomass

[9] Voegeli et al. (2009:4) find optimal temperatures ranging from 30-35 degrees Celsius; while Mkiramweni and Mshoro (2010:1361) report optimal temperatures between 23-37 degrees Celsius.

burning (Khalil, 2000), but uncertainty exists with respect to the individual contribution to methane emissions from these sources (Bogner and Matthews, 2003). Waste management is a major contributor to methane emissions as well; Bogner et al. (2008) estimate that waste management at present accounts for 18 percent of total methane emissions, which equals 3 per cent of total GHG emissions (Bogner et al., 2008; UN-Habitat, 2011).

While emissions from landfills in developed countries have largely stabilised, emissions from landfills in developing countries are likely to increase in the years to come (Bogner and Matthews, 2003; Monni et al., 2006). High urban population growth rates, higher per capita waste generation and increased affluence (Cointreau, 2006; Kennedy et al., 2011; UN-Habitat, 2011), in combination with improper waste management (Troschinetz and Mihelcic, 2009), causes higher emissions from developing countries (Bogner and Matthews, 2003; Couth and Trois, 2010). Monni et al. (2006) stated that developing countries were responsible for 29 per cent of global methane emissions in 2000[10], and estimate that methane emissions from developing countries will increase via 64 per cent in 2030 to 76 per cent in 2050, mainly due to increased emissions from landfills.

2.1.2 The Adoption of Biogas as Mitigation Strategy

Since waste is a major contributor to methane emissions from developing countries, several studies (Barry et al., 2011; Barton et al., 2008; Cofie et al., 2009) examined strategies to mitigate methane emissions from waste. Despite increasing atmospheric quantities of methane, changes in methane emissions can affect atmospheric methane concentrations on relative short timescales since methane has a relatively short atmospheric lifetime of about 10 years (Bogner and Matthews, 2003: 34). Controlled composting, recycling, reduced waste generation, expanded sanitation coverage and the exploitation of energy from waste, e.g. landfill gas, incineration, and biogas production with composting of the digestate are identified as measures to reduce methane emissions from wastes (Bogner et al., 2008; Cofie et al., 2009; Friedrich and Trois, 2011). Of these, small-scale biogas production from wastes with composting of the digestate are commonly considered as most appropriate mitigation strategy to reduce atmospheric methane emissions[11] (Barton et al., 2008; Mata-Alvarez, 2002;

[10] U.S. EPA (2006) findings depict similar results (30-40 per cent).
[11] Large-scale plants are often not commercially feasible, since it represents the highest capital cost option and is the most demanding in operations (Barton et al., 2008: 696). Moreover, GHG are emitted in the collection and

Müller, 2007; Weiland, 2010).

Being aware of the several classifications of biogas technology and its environmental-, social-, agricultural-, and economic benefits, the remainder of this study focuses on the dissemination of the technology via sector development in both urban and rural areas. To understand present-day cluster processes, first we provide a short examination of earlier economic development experiences.

2.3 Experiences with Economic Development

Early development interventions starting from the mid-1940s primarily had the aim to attain economic growth via large-scale centralised government planning (Eckstein, 1957; Fei and Ranis, 1964; Pike et al., 2006). The 1980s were characterised by the hegemony of neo-liberalism in the Western world and high debts and financial crises in most Latin-American, African and some Asian countries. This resulted in pressure exercised by the International Monetary Fund (IMF) and the World Bank (WB) on national governments in developing countries to minimize public sector activities (Hyden, 1994; Ruttan, 1996) and to adopt Structural Adjustment Programmes (SAPs)[12]. As a result, developing countries instantly had to rely on the operation of market forces (Thorbecke, 2006). The expectation was that structural adjustment would result in greater incentives for producers to engage in market transactions and that these incentives would result in higher levels of production and national economic growth (Hyden, 1994). Nevertheless, the instant reliance on market mechanisms with little regulation and market supporting mechanisms did not increase private sector investments in many African countries and markets did not function (Helmsing, 2003). Consequently, scholars argued that economic development in developing countries was impeded by low human capital endowment (Lucas, 1988; Romer, 1990) and lack of institutional infrastructures conducive to economic development (Commander et al. 1996; Dollar, Hallward-Driemeijer and Mengistae, 2005; Helmsing, 2003).

transport of waste from the combustion of fuel (Friedrich and Trois, 2011:1588), which neutralizes GHG emission savings.

[12] E.g. policies intended to result in macroeconomic stability (Thorbecke, 2006)

2.4 Current Emphasis on Cluster Formation

Because of increased insight in the weaknesses of earlier economic development interventions, at present it is acknowledged that multi-actor and multi-sector approaches, in which public-, private-, and non-governmental sectors act collectively, shape conducive environments towards local economic development (LED). LED interventions aim to foster the economic development of remote rural areas (Geddes and Newman, 1999; Goldman, 2005), while being embedded in the ecological, political, and cultural contexts of regions, thereby striving to reduce social inequality, promote environmental sustainability and encourage inclusive governance (Haughton and Counsell, 2004; Keating, 2005). The WB practices the following definition about LED (Swinborn, Goga and Murphey, 2006: 1):

"*The purpose of local economic development is to build up the economic capacity of a local area to improve its economic future and the quality of life for all. It is a process by which public, business and non-governmental sector partners work collectively to create better conditions for economic growth and employment generation."*

Processes to generate local economic development require the formation of effective local multi-stakeholder partnerships, wherein processes of knowledge creation and learning among small enterprises and entrepreneurs can bring benefits for regional socio-economic development (Breschi and Malerba, 2001; Helmsing, 2001). These local multi-sector partnerships are commonly referred to as 'clusters' (Fromhold-Eisebith and Eisebith, 2005; Wolfe and Gertler, 2004. A definition of clusters is provided by Fromhold-Eisebith and Eisebith (2005: 1251):

"A regional agglomeration of sector or value chain related firms and other organizations (like universities, R&D centres, public agencies) which derive economic advantages from co-location and collaboration."

Based upon the work of influential scholars in the field of local economic development, an earlier study by Schoot Uiterkamp and Pennink (2011) identified 7 constructs and 11 indicators, structured around the dimensions 'team of recipients-, institutional-, and enterprise' to assess the degree of sector development in a given geographical context. Their 'local capacity assessment model' is represented in table 2.1.

Table 2.1 Local Capacity Assessment Model

Level of Analysis	Construct	Indicator
Team of Recipients	Degree of internalisation of knowledge	Ownership of-, commitment to- and satisfaction with acquired knowledge
	Articulation of acquired knowledge	Action Plan approved by institution as development plan
Institutional	Hard infrastructure provisions	Availability of financial institutions, infrastructure provisions, governance, regulations, taxes, judicial and bureaucratic system
	Soft infrastructure development	Creation of linkages between public-, private- and non-governmental sectors
		Encouraging local business development by establishing knowledge centres, supportive institutions providing support for business start-ups
Enterprise	Business networks facilitating local learning	Creation of sector associations
		Establishment of agglomerations of local producers
	Degree of technological and organisational capabilities	Innovations and product diversification
	Competitiveness of sector	New business development
		Creation of jobs
		Attracting external investment

Source: Schoot Uiterkamp and Pennink (2011)

The local capacity assessment model has been applied in three different sectors in different geographic contexts in Indonesia and is considered valuable to understand processes of sector development in general. Nevertheless, it does not reflect the introduction of appropriate energy technologies in a certain geographical setting and thus the formation of clusters around energy technologies. In addition, the model does not specify to the African context. Therefore, the next section assesses to what extend the general sector development constructs as identified by Schoot Uiterkamp and Pennink (2011) can be adjusted to assess biogas cluster formation in Tanzania.

2.5 How to ‘Develop’ a Cluster and Who Takes the Lead?

As mentioned in the introduction of this study, most theories about technology clusters refer to existing clusters. Theories regarding existing clusters point at the important roles of agglomeration economies, where learning and innovations take place via networks effects (Bresnahan, Gambardella and Saxenian, 2001). Nevertheless, these ‘success’ elements are not in place since the beginning and it is hard to specifically point at the preconditions for cluster formation. However, Bresnahan et al. (2001) claim that two critical preconditions should exist. First, a plentiful supply of skilled labour (technical and managerial) forms the basis for entrepreneurship. Second, there should be market opportunities for the introduced technology.

Important roles exist for the public sector in the development of hard infrastructures to facilitate cluster development. Tvaronaviciene and Korsakiene (2007) state that government initiatives are required to increase the overall efficiency of multi-sector cooperation. Moreover, Fromhold-Eisebith and Eisebith (2005: 1254-1255) argue that private cluster initiatives are seldom initiated without encouragement, small participation, or benevolent acceptance by public actors. Nevertheless, it is important to consider that there is not ‘one-best-way’ to develop a sector via cluster approaches. Better, approaches should sensitise for the state of the sector to determine what approaches are feasible and based upon this analysis should be ‘top-down’ or ‘bottom-up’ (Breschi and Malerba, 2001). In situations where regional hard infrastructure is ill developed and which misses a vast entrepreneurial base and where actors are operating independently, public cluster policies might be a suitable initial choice, since these cover a broader, more diversified portfolio of activities that also includes location marketing, labour qualification and infrastructure support (Hartmann, 2002). Nevertheless, if infrastructure is relatively developed and ‘first mover’ companies in a sector exists with loose contacts to a large number of value chain related firms and other stakeholders, bottom-up initiatives are viable to foster cluster effects since they just provide the missing link (Fromhold-Eisebith and Eisebith, 2005).

The dynamics between public-, private-, and non-governmental sectors is best explained by dubbing actions ‘hard infrastructure development’ and ‘soft infrastructure development’. As mentioned, cluster formation processes involve LGAs, private sector, and non-governmental sectors (NGOs, trade unions, social, civic and religious). LGAs are identified to provide the right mix of local public goods and are responsible to develop local infrastructures, e.g. to provide hard infrastructure. In addition, LGAs should facilitate the establishment of clusters via which public-, private-, and non-governmental sector knowledge exchange takes place, e.g. to foster soft infrastructure development Entrepreneurs embedded in local clusters learn via knowledge spill over's and thereby increase their capacities (Helmsing, 2001; Pike et al., 2006; Storper, 1997).

In sum, top-down cluster promotion is considered more adequate to deliver infrastructures, is more inclusive and expansive and has wider regional economic impacts. Bottom-up initiatives on the contrary prove more viable in processes to support mutual processes of learning, create stronger motivation among cluster members and enhance faster outcomes of innovation-related collaboration affecting firm performance (Fromhold-Eisebith and Eisebith, 2005: 1265). However, even clusters evolved without direct public intervention are indirectly influenced by the wider national or regional policy framework like infrastructure or sector oriented support (Sölvell, Lindqvist and Ketels, 2003; Wolfe and Gertler, 2004).

After all, three important groups of stakeholders are identified in processes to form technology clusters, the public-, private-, and non-governmental sectors. Therefore, section 2.6 and 2.7 introduce the important conditions facilitative to technology cluster formation at the institutional and enterprise dimension.

2.6 Cluster Formation: The Institutional Dimension

2.6.1 National Institutional Framework

A country or region's investment climate provides incentives and disincentives for starting and running a business (Dollar et al., 2005). The investment climate is referred to as the opportunities and incentives for starting and running a business productively, create jobs, and expand. Operationalizations of investment climate include availability of financial services, infrastructure, governance, regulations, taxes, labour, and conflict resolution (Dollar et al., 2005). In sum, an investment climate conducive to entrepreneurial behaviour is important to improve productivity and to create employment and ultimately reduces poverty (Dollar et al., 2005; Kinda and Loening, 2010; WB, 2004b). Kristiansen (2001:65) argues that in order to set up innovative business ventures requires a transparent, clean and well-organized bureaucratic and judicial system. Traditional trustworthiness based on 'the economy of affection' needs to be substituted by formalised systems of trust at a level above blood, kin or local community. Financial options must be created and formalised systems of trust based on law must be developed to reduce individual business risks. To support the dissemination of new energy technologies in particular, Parawira (2009) states that governments should support appropriate technologies through focussed energy policy.

2.6.2 Local Institutional Framework

At local levels, it has been noted (Breschi and Malerba, 2001) that government policies play important roles in cluster development by accommodating the formation of new firms, investment in education and the provision of support infrastructures. Moreover, due to recent governmental decentralization in many developing countries, the responsibilities of LGAs increased (McEwan, 2003). Consequently, long-term vision and planning capacities of LGAs are required at present (Lindert, van 2008; UN-Habitat, 2005). Besides the role of LGAs in the formation of local clusters, small firms and entrepreneurship are examined as a crucial part of a well-functioning regional economy (Malecki, 1997).

Audretsch, Bonte and Keilbach (2008) acknowledge the central role of knowledge based entrepreneurship in the process of economic growth and the prominent role of the public sector to encourage the transformation of generally available knowledge into viable new products and technology by developing entrepreneurship policy. Nevertheless Audretsch et al. (2008) argue that a focus solely on improvements of public infrastructure and the provision of risk capital to encourage entrepreneurs may not be sufficient. Instead, the public sector should actually support entrepreneurs as they navigate the bureaucracy to start new businesses, seek money to start their firms and provide support when the entrepreneur has problems. Specified to the rural energy needs in developing countries; Banks et al. (2008) refer to the establishment of 'integrated rural energy utilities' (IREU), to fulfil rural energy needs. IREU's are defined as decentralised energy centres that deliver a range of renewable and other energy services to primarily rural regions (*ibid*).

2.7 Cluster Formation: The Enterprise Dimension

The previous section addressed the institutional dimension to facilitate new technology cluster formation. The present section addresses the important roles at the enterprise dimension to develop successful technology clusters.

2.7.1 Energy Networks Facilitating Local Learning

Small firms and entrepreneurs benefit of being embedded in regional clusters (Breschi and Malerba, 2001) since it is likely that their productivity increases due to better access to specific information (Kristiansen, 2001; Navickas and Malakauskaite, 2010). Other benefits of clusters for small firms and entrepreneurs are a broad supply of labour force, easy access to capital resources, reduced costs of operation due to economies of scale and finally, benefits of cooperation since cluster company activities complement one another (Humphrey and Schmitz, 2008; Navickas and Malakauskaite, 2010).

Within local clusters, which are identified as multi-sector partnerships, the formation of bottom-up initiatives, as referred to in section 2.5, create mutual processes of learning, higher innovation levels and consequently improved firm performance. The creation of membership-based network organisations is the means to create local processes of inter-firm networking (Fromhold-Eisebith and Eisebith, 2005). Barr (1998) states that it is of benefit for entrepreneurs to be embedded in networks since it affect enterprise performance directly by providing information about the wider world, in particular about technologies and emerging market opportunities. Moreover, McCormick (1996) states that networks enhance trust relationships, which can link entrepreneurs of similar ethnicity or profession. The emphasis on learning via networks is referred to as creating ‘social capital’ (Coleman, 1988; 1990; Woolcock, 1998). Woolcock (1998) refers to social capital as “*the information, trust, and norms of reciprocity inherent in one’s social networks”.* Close inter-firm contacts are important to learn since knowledge can only be effectively transmitted through interpersonal contacts and inter-firm mobility of workers Breschi and Malerba (2001: 818).

2.7.2 Degree of Technological and Organisational Capabilities

Thus, from the above mentioned it can be derived that it is of value for entrepreneurs to be embedded in clusters in general and to be embedded in local inter-firm networks in particular to optimally benefit from public support and inter-firm learning to spur innovations. Hereby, local multi-stakeholder networks are important means to facilitate enterprise learning processes (Goldman, 2005; Humphrey and Schmitz, 2008; Melese and Helmsing, 2010). Interactions and cooperation between enterprises are seen as important processes of knowledge spill-over (Helmsing, 2003; Humphrey and Schmitz, 2008), which results in the ability of firms to obtain increased technological and organisational capabilities which makes them able to upgrade activities (Melese and Helmsing, 2010).

2.7.3 Competitiveness of Sector

The entrance of new firms in a sector has several implications for overall competitiveness and level of innovation within a given technology cluster. New firms result in increased efficiency and stimulate productivity increase due to competition between firms. In addition, the entrance of a newcomer brings greater availability and variety of products and problem solutions since newcomers can introduce significant process innovations. After all, the entrance of new firms has an impact on the demand-side as well since a greater variety of products implies a higher probability that products better matches customer preferences. Consequently, through newcomers, increased competition, innovation and better matches with customer preferences, significant impulses for cluster formation can be generated (Fritsch, 2008). Reuber and Fisher (2001) identify a similar relationship between the effect of new firms on competition and innovations. They state that clusters are perceived as important mechanisms to spur innovations and dynamic economic development since cluster companies are motivated to compete with one another, which creates innovativeness.

2.7.4 Entrepreneurial Characteristics and Behaviour

As mentioned in section 2.5, the supply of skilled labour is a critical condition to stimulate entrepreneurship and cluster formation. Entrepreneurs are defined as follows (Kristiansen, 2001: 44):

"*An individual or a group of people, initiating the provision of products or services to a market, representing something new in that given context.*"

Brockhaus (1982) argues that (potential) entrepreneurs should possess three attributes, namely: having a need for achievement, an internal locus of control[13] and a risk-taking tendency. Bull and Willard (1995) add three behavioural conditions; these are task-related motivation of entrepreneurs, expertise of entrepreneurs and expectations of economic and /or psychic benefits. Together the behavioural conditions determine the willingness to innovate, take risk and be proactive (Nkya, 2003: 48). However, Nkya (2003) argues that

[13] The perceived level of autonomy vis-à-vis factors that determine successes and failures in life (Brockhaus, 1982)

entrepreneurial behaviour should not be considered as a constant situation, it can be developed over time. Three entrepreneurial behavioural stages can be identified. The first stage is the strengthening of attitudes and commitment to hard work, originality and risk-taking. Then, in the second stage, entrepreneurs have to pick opportunities, identify new markets, create the means of production and open the market. In the last stage, entrepreneurs should navigate through obstacles once providing the new service or product on the market (*ibid).*

In addition, the behaviour of entrepreneurs is likely to be affected by the level of education potential entrepreneurs assess. King and McGrath (1998) state that the level of human capital in the entrepreneur has a positive impact on firm growth. In addition, entrepreneurs with larger stocks of human capital in terms of education and / or vocational training are better able to adapt their enterprises to a constantly changing business environment (Ardichvili et al., 2003; Mead, 1998; Goedhuys and Sleuwaegen, 2000). Enhancing entrepreneurial capacity can be done via training, logistical support, financial support, networking or via a supportive institutional framework (Nkya, 2003: 44). Especially in an era of globalisation, there is a growing need for entrepreneurs and their workers to become 'clever' in order to respond to the challenges of an increasingly competitive market environment (McGrath and King, 1996). It is for this reason that several scholars argue that business development services 'have a key role to play in stimulating innovation and promoting self-sustained growth (Dawson and Jeans, 1997).

The previous sections examined the conditions to stimulate technology cluster formation at institutional- and enterprise dimensions. Nevertheless, as argued in the introduction of this study, also the wider economic, social, political and cultural factors determine whether required technological capabilities will be developed. The next section therefore discusses contextual dimensions, and specifies for biogas, which determine whether appropriate energy technology capabilities are generated.

2.8 Cluster Formation: The Contextual Dimension

2.8.1 Societal Acceptance Entrepreneurship

The previous section identified institutional- and enterprise- dimensions, which are of importance for cluster formation. However, a contextual factor, which affects entrepreneurship formation, is the society. Dana (1993) argues that the most critical element in entrepreneurship development is the value society attaches to business. Specified to environmentally responsible entrepreneurship, Meek, Pacheco and York (2010) find that the impact of policies to stimulate environmental responsible entrepreneurship largely depends on the social norms in the networks of (potential) entrepreneurs. This reflects the general acceptance to strive for individual progress and prosperity in the social environment.

2.8.2 Degree of Adoption Introduced Technology

Despite all conditions, which facilitate the development of entrepreneurs in a given context, Bresnahan et al. (2001) identified market potential for a given technology as second important prerequisite for cluster formation. Therefore, this section discusses determinants to adopt biogas technology. In a study by Ji-Qin and Nyns (2005) it is observed that demand for biogas digesters is affected by the adopter's economic condition; the availability of biogas fermentation resources; the local energy situation and the availability and accessibility of alternative energy technologies; and the provision of technical assistance to users of the biogas technology. In addition, in an examination of opportunities and constraints to adopt bio digesters from an earlier biogas programme in Tanzania, Mwakaje (2008) finds low affordability, water scarcity, lack of awareness and poor performance due to lack of technical expertise producers as constraints for household adoption of biogas. Several authors (Marree and Nijboer, 2007; Parawira, 2009; Quadir, Mathur and Kandpal, 1995) mention low functionality of biogas digesters due to quality problems as barrier to further dissemination. Subsequently, Quadir et al. (1995) further mention high investment costs, long payback period, unavailability of sufficient input materials, lack of perceived needs, unwillingness to adjust to the changes in lifestyle and disharmony with prevailing values and ideology as barriers towards adopting biogas technology. Finally, Martinot et al. (2002) find that the presence of market facilitation organisations is viable to raise greater attention to social benefits and income generation opportunities of introduced technologies.

2.9 Chapter Conclusion

After all, based upon analysis of institutional-, enterprise-, and contextual dimensions of relevance for biogas cluster development as identified in sections 2.6, 2.7 and 2.8, we are confident to adjust the local capacity assessment model of Schoot Uiterkamp and Pennink

(2011) and create the proposed Appropriate Energy Model. Thereby, figure 4.1 presents the conceptual framework of this study while table 4.1 presents the proposed Appropriate Energy Model. The next chapter introduces the geographical context in which the dissemination of biogas should be assessed.

3. BIOGAS: WILL IT HEAT ALL AFRICAN MEALS?

The previous chapter identified the conditions to apply biogas technology and discussed strategies for biogas cluster formation. This chapter provides an overview of the need and potential for biogas technology in African countries in chapter 3.1. Subsequently, chapter 3.2 presents the Tanzanian context, followed by the Tanzanian current energy situation and the need and potential for biogas. Finally, chapter 3.3 formulates four assumptions regarding the potential of biogas cluster formation in Tanzania.

3.1 Energy in Africa

3.1.1 Status Quo

African countries spend high amounts of their foreign exchange earnings to import fossil fuels (Karekezi, 2002; Kiplagat et al., 2011), while electricity access in most African countries varies between 10 per cent (Mshandete and Parawira, 2009) and 24 per cent (Barry et al., 2011) of total population, with far lower access rates for rural population (Kiplagat et al., 2011). Murphy (2001) states that even where rural areas are connected to the electricity grid, only the wealthiest rural residents can afford connections. Besides low affordability, the low access rate to electricity is possibly explained by the decentralised nature of human settlements (Hiremath et al., 2007), which implies high distribution costs for centralised power systems and a need for high technical-, and managerial capabilities (Karekezi, 2002; Mbuligwe and Kassenga, 2004). After all, 94 per cent of the African rural population and 73 per cent of the urban population use low quality biomass energy sources in the form of firewood and charcoal as their primary source of energy[14] (Bailis et al., 2005). Hereby, firewood is mainly used in rural areas, whereas the urban poor primarily use charcoal. The remaining households use a combination of kerosene, liquefied petroleum gas (LPG) and to a limited extent, electricity (Bailis et al., 2005). The impacts of the current energy provision on human health and environmental conditions are examined in the previous section.

3.1.2 Plea for Small-Scale Energy Provisions

The reliance on traditional biomass fuels for cooking causes 400.000 annual deaths in Africa since the combustion of biomass fuels emits pollutants (Ezzati et al., 2002). In

[14] Similar percentages are found by Murphy (2001).

addition, the overreliance on biomass energy sources causes severe deforestation, soil erosion, desertification, loss of biodiversity (Karekezi, 2002; Kassenga, 1997) and low quality of life (Hiremath et al., 2007). Several scholars (Karekezi, 2002; Mbuligwe and Kassenga, 2004) have noted that African countries have too limited financial resources and technical and managerial expertise to develop comprehensive centralised energy sectors. Therefore, it is unlikely that the present status quo will change via centralised energy strategies of national governments. Despite it, African countries have abundant, diverse and unexploited biomass and other renewable energy sources, which are deemed suitable for decentralised small-scale energy provisions (Barry et al., 2011; Karekezi, 2002; Mshandete and Parawira, 2009). Therefore, it has been postulated (Friedrich and Trois, 2011; Hiremath et al., 2007; Karekezi, 2002; Kiplagat et al., 2011) that African countries should begin to develop decentralised energy structures which better matches their capital resources, management ability and infrastructure instead of continuing to expand their centralised power systems. For these reasons, some authors argue that biogas could address local energy needs (Kassenga, 1997; Msandete and Parawira, 2009). As a result, efforts to improve and modernise small-scale biomass energy systems to ensure environmentally sound use of biomass energy are components of national energy strategies in many African countries at present (Karekezi, 2002).

Besides the potential of biogas to fulfil energy needs in Africa, biogas has the potential to address waste management issues as well, as will be addressed in the next section.

3.1.3 Energy Needs, Waste Volumes and Increasing Emissions

For 1994, it was reported that the African continent had the lowest aggregate GHG emissions with the equivalent of 1.6 billion tonnes carbon dioxide annually. Moreover, the average per capita emissions on the African continent were lowest as well (UNFCCC, 2005). Of the African countries, South Africa (24 percent) and Nigeria (15 percent) have highest emissions within Africa. Thus, derived from current African GHG emissions, GHG mitigation strategies might not be of high priority at the African continent. Moreover, African countries have some of the lowest waste generation rates per capita (Couth and Trois, 2010; Friedrich and Trois, 2011) as well. When translated into methane emissions, municipal solid waste accounts for most of the methane emissions, while rural areas have very low contributions (Couth and Trois, 2010). Nevertheless, the continent faces high population growth, accompanying higher waste volumes and increased energy demand, especially in urban areas[15] (UN-Habitat, 2010; 2011). In addition, as mentioned in the previous sections, most Africans are dependent on low-quality biomass energy sources for cooking (Bailis, Ezzati and Kammen, 2005). For these reasons, it is likely that GHG emissions from energy consumption and wastes will increase. Especially when the composition of current GHG emissions are regarded: energy (49,1 percent) and waste (6,8 percent) (UNFCCC, 2005); biogas solutions are considered appropriate to mitigate higher future emissions. The composition of urban non-agricultural wastes is suitable for the production of biogas since several studies (Asomani-Boateng and Haight, 1999: 412; Barton et al., 2008: 691; Cofie et al., 2009: 257; Friedrich and Trois, 2011: 1587) find that waste in African cities is high in organic, biodegradable matter[16]. Moreover, in several African rural areas, sufficient livestock are available to produce agricultural input wastes to fulfil rural energy needs with biogas (Karekezi, 2002; Mshandete and Parawira, 2009).

In sum, from a needs perspective there is a role to play for small-scale decentralised energy provisions in Africa. Moreover, it has been stated that sufficient biomass is available to generate biogas. Since this analysis provides at best an overview of the general potential of biogas, the previous section zooms in on the specific characteristics in Tanzania, which determine whether biogas solutions are actually applicable in Tanzania.

3.2 Tanzania

Where the previous sections provided a general picture of the biogas potential in Africa, this section introduces the Tanzanian context and presents the conditions for biogas in Tanzania in three sections. First, general national level characteristics are provided. Second, the status of the Tanzanian energy sector will be explained and derived from that, the national socio-economic potential for biogas dissemination is examined.

---

[15] At present, almost 40 per cent (395 million) of African population lives in urban areas and projections are that urban population triples in the next forty years, to reach 1.23 billion inhabitants by 2050, or 60 per cent of total African population (UN-Habitat, 2010).

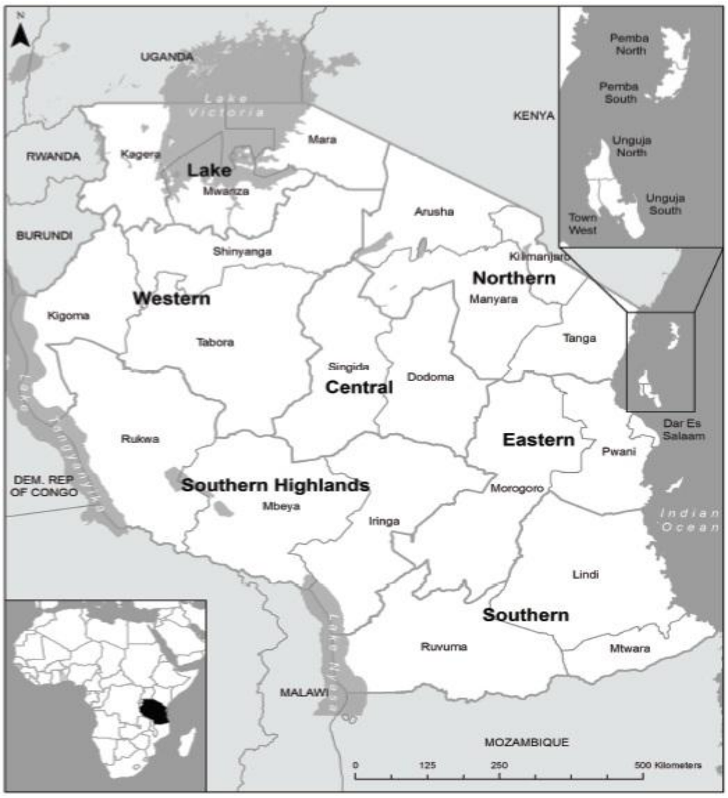
[16] Derived from independent analysis of waste composition in urban areas of 9 African countries. Findings show proportions of biomass in waste of 59, 8 per cent (Friedrich and Trois, 2011); 72,2 per cent (Asomani-Boateng and Haight, 1999) and 75-80 per cent (DFID, 1999)

3.2.1 General National Context

3.2.1.1 Geography

Tanzania is situated in East-Africa. With area coverage of 940.000 square kilometres, it is the largest country in East-Africa. Tanzania lies south of the equator and shares borders with eight countries: Mozambique, Malawi and Zambia in the South; the Democratic Republic of Congo (DRC), Burundi and Rwanda in the West, and Uganda and Kenya in the North. Tanzania borders the Indian Ocean in the East and just off the coast of the mainland, the archipelago of Zanzibar is located, which forms a semi-autonomous part of Tanzania. Tanzania's area coverage includes 60.000 square kilometres of water, which include the world's second largest and second deepest lake, Lake Victorica and Lake Tanganyika respectively. The Rufiji River is Tanzania's largest river; it drains into the Indian Ocean south of Dar es Salaam. Two branches of the Great Rift Valley run through Tanzania and are thereby Tanzania's most distinctive geological features. Mount Kilimanjaro in the North is with 5895 metre the highest point in Africa (Government of Tanzania (GoT, 2011a)).

Map 3.1. Geographical Location Tanzania



Source: Government of Tanzania (2011)

3.2.1.2 Political Situation

Julius Nyerere became the republic's first leader after Tanzania became independent of British colonial rule in 1961 (GoT, 2011a). Nyerere's distinctive collective economic vision is known in Swahili as *ujaama*. This form of socialism yielded a sense of national unity but economic development was not achieved (Freedom House, 2010). At present, Tanzania is governed under a multiparty democratic system, with presidential and national assembly elections every five year, with a maximum of two terms for the president (GoT, 2011a). Since 2005, Jakaye Kikwete is Tanzania's president; het prolonged his presidency in the elections of October 2010 (Freedom House, 2010).

3.2.1.3 Demographic Situation

With 23.6 per cent of all East African population living in areas classified as urban by 2010, the level of urbanization in Eastern Africa stood significantly lower as compared to the African average of 40 per cent. Despite the lower current urbanization level; the East African annual urban population growth rate for the period 2005-2010 is with 3.86 annually, higher than the African average of 3.3 per cent. Hereby, it is expected that the East-African urban population will increase with nearly 40 million to 116 million by 2020, whereby one-third of all East-Africans live in areas classified as urban (UN Habitat, 2010). For 2007, it was estimated that Tanzania 38 million people resided in Tanzania mainland (NBS, 2009), which excludes Zanzibar. Estimates for 2011 are a total population of almost 43 million, which includes Zanzibar (CIA The World Fact Book, 2011). Tanzania's population growth rate is 2 per cent per annum (UN DESA, 2007) and with 74,8 per cent, the majority of population lives in areas defined as rural (NBS, 2009). Nevertheless, urbanization rates are high; over a time-span of 15 years (1992-2007), the share of urban population increased with 40.8 per cent, from 17.9 per cent in 1992 to 25,2 per cent in 2007 (Calculation based on NBS, 2009 data).

Income levels in the predominantly agricultural, rural areas of Tanzania are lower, rural poverty is more widespread and poor inhabitants depend to a large extend on environmental resources for survival, noticeably forest products (GoT, 2009: GoT, 2000). Expressed in statistics, 12.9 million Tanzanians lived below the basic needs poverty line in 2007 (GoT, 2009; NBS, 2009) and food poverty declined from 21.6 per cent in 1991 to 16.6 per cent in 2007. Especially rural areas in regions central, southeast and northeast Tanzania are vulnerable to hunger and food insecurity (UN Tanzania, 2011). The population is divided over more than 120 ethnic groups, among which the Sukuma and Nyamwezi represent the largest ethnic groups. The population is irregular distributed over the country, with high densities near fertile soils around Kilimanjaro and Lake Malawi, while population densities are lower in the centre of the country (UNEP, 2011).

3.2.1.4 Economic Structure

Tanzania's production structure depends largely on agriculture (Jung and Thorbecke, 2003). Estimations are that 70 per cent (IFAD, 2010b) to 82 per cent (GoT, 2003a) of the employed workforce finds employment in agriculture, forestry or fishing and 60 per cent of exports stem from agricultural products (IFAD, 2010b). In the years 2008 and 2009, Tanzania's GDP grew with 7,4 and 6 per cent respectively, to reach the equivalent of €308 per capita in 2010 (GoT, 2011a). Corrected for price levels between countries, Tanzania's GDP per capita is USD 1400 (CIA The World Fact Book, 2011). Tanzania's industry relies mostly on processing agricultural products and light consumer goods (Jung and Thorbecke, 2003). Tanzania has the potential to exploit the agricultural sector to even larger extends since only a third of the arable land is being cultivated at the moment, and recent donor-funded programmes show that the productivity can be tripled (IFAD, 2010b).

Nevertheless, the recent growth of the economy is in particular explained by increases in GDP per capita in services (GoT, 2011). At present, services account for 47, 6 per cent, agriculture, hunting and forestry for 26, 9 per cent, industry and construction for 24 per cent and the fishing sector for 1, 5 per cent of total GDP per capita (GoT, 2010a).

3.2.1.5 Level of Human Development

Despite the recent GDP per capita growth, Tanzania is still characterised as a country with low human development, it ranks 148 of 169 countries on the United Nations' 2010th 'Human Development Index' (UNDP, 2010)[17]. The population composition depicts a young population, where 69 per cent is under 30, while only 4.4 per cent of total population is 64 years of age (NBS, 2009). By the early 1980s, Tanzania came close to achieve 'Universal Primary Education'[18] (Wedgwood, 2007), which might be explained by the extensive social

[17] The Human Development Index consists of three measurement criteria, namely life expectancy at birth, average years of education and GDP per capita (Szirmai, 2005).
[18] A figure used to express the percentage of primary-school aged children in schools (Wedgwood, 2007)

services provided to rural households under the *ujamaa* philosophy. After Tanzania's transition into a market-led economy by the end 1980s (IFAD, 2010a), the UPE rate went down to reach less than 60 per cent by 2000 (Wedgwood, 2007: 386). Subsequently, primary school fees were abolished in 2001, which led to increases in enrolment rates to reach 70 to 100 per cent at present. Despite higher enrolment rates, the quality of primary education is low with a pupil/teacher ratio of 54:1 in 2009, insufficient qualified teachers and improper classrooms. Consequently, the passing rate of public primary schools was only 49.4 per cent in 2009 (UN Tanzania, 2011).

3.2.2 Energy in Tanzania

Being aware of the general geographic and socio-economic conditions of Tanzania, the present section will assess the current energy situation and identifies small-scale energy solutions to address previously ignored energy needs of rural areas and the urban poor without compromising on human health and the environment.

3.2.2.1 Access to- and Affordability of- Electricity and Petroleum

Hydroelectric energy is the most developed energy technology in Tanzania. More than 90 per cent of electricity is generated by hydropower plants (Kassenga, 1997), whereby the energy sector accounted for 17,6 percent of total GHG emissions in Tanzania in 1994 (UNFCCC, 2005). Household access to the central electricity grid in Mainland Tanzania is nonetheless limited to 12.1 per cent of households, while access in rural areas stands significantly lower at 2.5 per cent (NBS, 2009). The low access to the central electricity grid in rural areas is caused, amongst others, by the population spread. Households are scattered throughout a vast area, which makes connection to the central electricity grid and distribution of fossil fuels commercially unfeasible. Despite liberalisation of the energy sector since late 1980s, progress for the rural poor in terms of access and affordability were not achieved (Kammen and Kirubi, 2008: 349-50). Since Tanzania has not found extractable oil resources on its own territory, it is completely dependent on imported petroleum. In the National Energy Policy published in 2003, the annual demand is estimated on 1.2 million tonnes of oil, which costs 25 to 40 per cent of the total export value, depending on petroleum prices (GoT, 2003b).

The main purchaser of petroleum is the transport sector, while households purchase 10 per cent of the petroleum products, which consists mainly of kerosene (GoT, 2003b).

3.2.2.2 Household Energy Consumption

In Tanzania, like in many other African countries, the non-commercial biomass fulfils a large role in domestic energy supply, whereas commercial energy sources are only available for 3 per cent of the population (WHO and UNDP, 2009). The biomasses firewood and charcoal represent the main sources of energy for cooking for 95,8 per cent of the population[19] (GoT, 2009). The use of charcoal for cooking in urban areas increased to 71 per cent and replaces paraffin due to higher kerosene prices. Charcoal gains in demand in rural areas as well, as used by 4 per cent of rural population in 2001 to 7 per cent in 2007 (*ibid*). About half of the charcoal needs stem from the commercial capital Dar-es-Salaam that is expected to double its demand within 20 years (WB, 2009). Paraffin still provides the main source of energy for lighting nationally, used by 83 per cent of households (NBS, 2009). Not only poor people increasingly use charcoal, the affordability of electricity among the middle class declines as well due to a 25 per cent increase in prices over a period of one and a half year starting from December 2010 (Reuters, 2011). In addition, between 2003 and 2007, the price of charcoal has increased by five times in Dar-es-Salaam (WB, 2009).

3.2.2.3 Socio-Economic and Environmental Threats

The reliance on biomass energy sources for cooking has severe impacts on human health, especially for children. In Tanzania, 84 out of every 1000 Tanzanian children under the age of five are suffering from pneumonia. This high percentage can largely be contributed to in-house air pollution through combustion of solid fuels, since young children have a two to three times greater risk of developing respiratory illnesses when raised in families using solid fuels (Fullerton et al., 2008; WHO and UNDP, 2009).

Moreover, the overreliance on biomass for cooking has exerted considerable pressure on the remaining forest stocks, thereby accelerating the processes of land degradation. Tanzania’s forest covers 33 million hectares and provides the means to capture carbon dioxide emissions and convert the gas through a chemical photosynthesis process. Nevertheless, the

[19] A similar percentage is found by Mwakaje (2008), who finds that a share of 97.7 per cent of all household energy used for cooking, heating and lighting is derived from biomass.

forest is at risk to disappear because of large-scale logging. Estimates on the rate of deforestation differ from 230,000 to 420,000 hectares per annum. The production of charcoal causes much of the deforestation, e.g. 125.000 hectares annually, since the production of one kilogram of charcoal requires 6 kilogram of wood input. In addition to the decline in forest cover, logging is also associated with high emissions of greenhouse gases. For this reason, the conservation of woodlands and forests therefore also reduces GHG emissions (WB, 2009). The high share of the population which rely on biomass energy sources, in combination with increasing energy demand due to a population growth of two per cent per annum (UN Desa, 2007), results in decreases in the available biomass (FAO, 2005). Besides increased population pressure, the per capita demand for energy increases as well, for instance due to increased demand for electrical appliances (IEA, 2007). Because of increased energy demand, it is challenging to meet future energy demand without rapidly depleting natural resources. In sum, continuation of the status quo where household use a traditional energy source with the same level of efficiency while management of natural resources is poor, will cause an increase in prices, resource poverty and environmental degradation (WB, 2009).

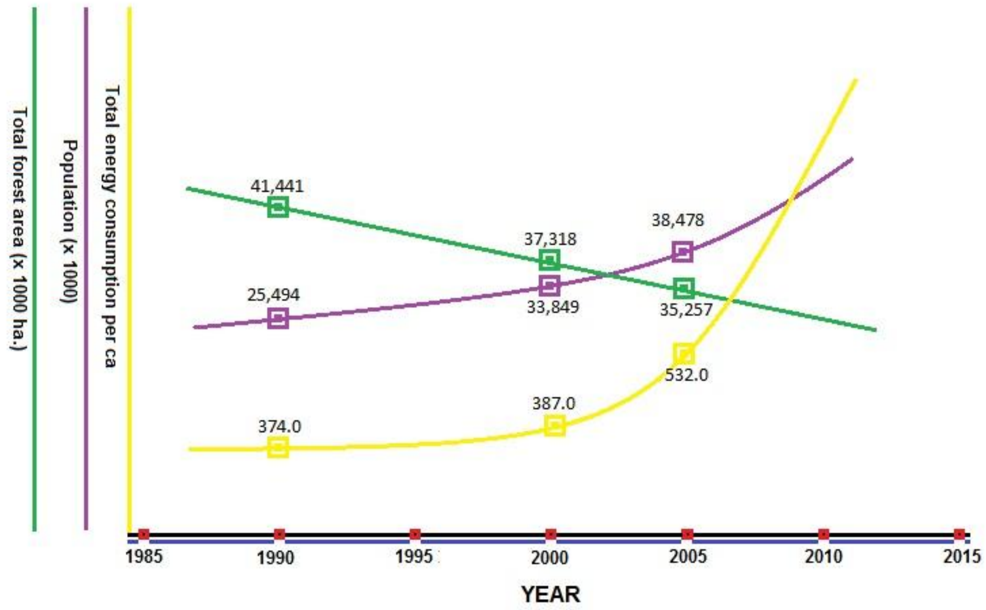
Table 3.1. Dynamics of Energy Demand and Supply in Tanzania

Year	1990	2000	2005
Population in thousands (growth of approximately 2 per cent per annum) (UN DESA, 2007)	25,494	33,849	38,478
Annual energy consumption per capita* Units: Kilograms of oil equivalent (kgoe) (IEA, 2007)	374.0	387.0	532.0
Total forest area** Units: thousands hectares (FAO, 2005)	41,441	37,318	35,257

* *Total energy consumption per capita* measures the amount of primary energy consumed, on average, by each person living in a particular country or region for the year indicated. All primary sources of energy, including coal and coal products, oil and petroleum products, natural gas, nuclear, hydroelectric, etc., are included here. Data are studied in kilograms of oil equivalent (kgoe) per person.

** *Total forest area* is determined by both the presence of trees and the absence of other predominant land uses. Land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 per cent, or trees able to reach these thresholds, such as areas under reforestation and areas temporarily unstocked but expected to regenerate, are considered forests. Forest area does not include land predominantly under agricultural or urban land use, such as tree stands in fruit plantations and agro forestry systems, or urban parks and gardens. Data are measured in thousand hectares.

Figure 3.1 Dynamics Of Energy Demand And Supply In Tanzania[20]



3.2.2.4 Energy Problems Addressed: A Focus on Small-Scale Energy

As the previous section underlined, the current and increasing reliance on wood fuels to fulfil Tanzania's energy demand causes human health problems and is inaccurate to cater for future energy demands of the population, without the depletion of environmental resources. The GoT acknowledges the urgent situation and states that it is critically important that fuel-efficient stoves and other technologies be adopted to minimise environmental degradation (GoT, 2009:57). In addition, the GoT (2010b: 54) states in the National Strategy for Growth and Reduction of Poverty II (NSGRP II) that Renewable Energies (RE) like solar, wind, mini-hydro and biogas should be expanded in rural areas since distribution costs of electricity are disproportional high in rural areas (GoT, 2010b). In accordance with the statement of the GoT not to expand the electricity network in rural areas, Kammen and Kirubi (2008:349-350) conclude that off-grid decentralized power systems where small private companies or community organizations can provide energy through ARETs seems to better fit the requirements of rural Tanzania. Hence, from 2000 onwards Tanzania embarked on a new drive to achieve rural access to energy, via national government rural energy strategies (GTZ, 2007; GoT, 2010b) and by government decree the Rural Energy Agency (REA) and Rural Energy Fund (REF) were created in 2005 as agency of the Ministry of Energy and Minerals

[20] Note: Deforestation is not solely caused by household energy consumption patterns. Nevertheless, the logging to fulfill household energy needs is a major contributor to deforestation (see section 2.2.2.4).

(GoT, 2005). Besides the government attention for rural energy, several non-governmental biogas initiatives take place in Tanzania, as referred to in the introduction.

3.2.3 National Biogas Potential

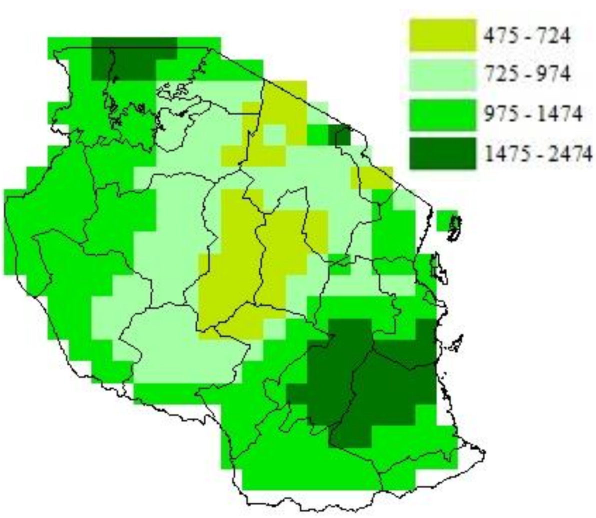
This section addresses the conditions and potential for biogas in Tanzania and introduces earlier and current biogas dissemination initiatives in both urban- and rural areas.

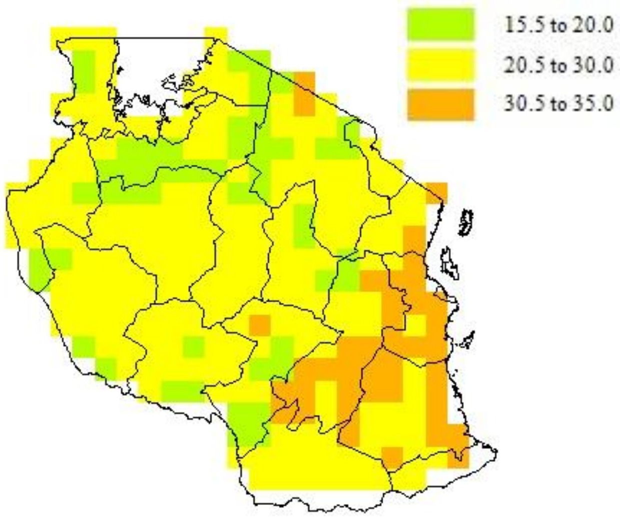
3.2.3.1 Climate and Environmental Conditions

In general, Tanzania is subdivided in three geographic zones: lowland-, highland-, and plateau-zones. The lowland is mainly located in the West and South-West of Tanzania, the plateau in the East and the highland in Northern and Mid-Tanzania. The lowland consists of wet, moist and dry subzones, where rainfall respectively is classified from 1800 mm or higher, 1800 to 1000 mm and 1000 to 750 mm annually. The highland zone consists of moist highland with 1000 to 1800 mm and the dry highlands with 625 to 1000 mm annually. Finally, the plateau zone with again a moist and dry subzone roughly corresponds to the aforementioned moist and dry subzones in highland zone (FAO, 2011). Most precipitation along the coast and around Mount Kilimanjaro falls in the period March to May, while short periods of rain occur between October and December. The rainfall in the Western part of the country is well distributed throughout the year, with the peak falling between March and May. After the main rainy season from March to May, most parts of the country face a long dry spell from May to October, with cooler temperatures. Subsequently, between November and April, precipitation levels increase (GoT, 2011a).

Derived from the climatic conditions, we postulate that the average annual temperature in most part of the country is slightly below the preferred temperature of around 30-35 degree Celsius to receive optimal biogas yields. When the level of precipitation is considered, it is derived from map 3.4 that precipitation is erratic in Northern Tanzania. Moreover, map 3.2 demonstrates that several regions in Central- and Northern- Tanzania are characterised as dry to very dry, while plenty and stable precipitation is required for biogas production. Based upon the climatic conditions, the potential for biogas are best in South Eastern Tanzania, where suitable temperatures over 30 degrees Celsius and high annual precipitation are noted.

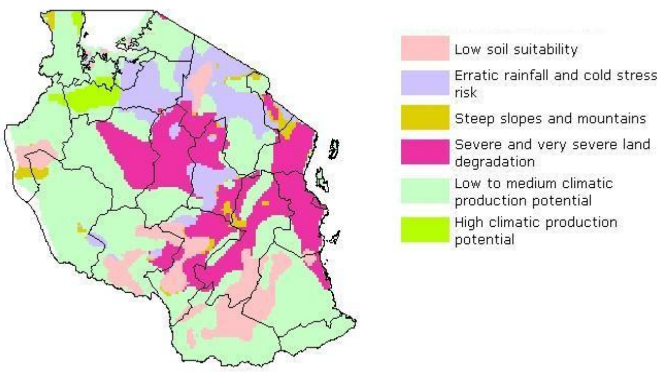
Map 3.2 Average Annual Precipitation (mm)Map 3.3 Average Annual Temperature (°C)

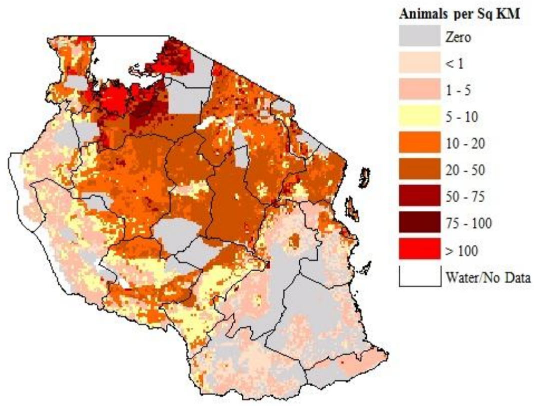




Source: FAO (2011)

Map 3.4 Environmental Status   Map 3.5 Feedstock per Square Kilometre





Source: FAO (2011)

3.2.3.2 Available Biomass

With a total cattle population of 15 million in 1997 (Kassenga, 1997) and 18,8 at present, Tanzania is the third country with largest cattle population in Africa, after Ethiopia and Sudan (Mshandete and Parawira, 2009). Kassenga (1997) estimates that the total cattle population produces more than 40 million tonnes of agricultural wastes, e.g. manure, per annum (Kassenga, 1997). Despite Tanzania's large cattle population, the lion share of cattle is indigenous breed, owned by small owners, predominantly pastoralists in Northern Tanzania (GoT, 2011b). Pastoralists allow their livestock to roam while feeding, which makes it of limited use to generate biogas (Murphy, 2001; SNV, 2009). In addition, for pastoralists, bio digesters are not beneficial year-round since their settlements are often seasonally abandoned in the quest for water and fodder (Murphy, 2001). Therefore, the number of dairy cattle is perceived a more appropriate indicator for biogas potential since dairy cattle are zero grazing. Tanzania's dairy cattle population is approximately 400.000 (SNV, 2009).

In the economic capital city of Tanzania, Dar es Salaam, non-agricultural solid waste of 2500 tonnes a day is generated (Kassim and Ali, 2006). Translated into waste generation per capita, it was found that the average daily per capita waste generation in Dar es Salaam was 0.39 kilogram in 1996 (Kaseva and Gupta, 1996), while Kaseva, Mbuligwe and Kassenga (2002) find a per capita waste generation rate of 0.36 kilogram per day. Of total solid wastes, 67 per cent consists of organic matter (Mbuligwe and Kassenga, 2004), and are thereby suitable for biogas production. Nevertheless, approximately 48 percent of total waste generated is collected and transported for final disposal (Kassim and Ali, 2006), and therefore unnecessary contribute to the shortening of the life span of landfills and disposal sites (Diamadopoulos, Koutsantonakis and Zaglara, 1995; Kasseva and Gupta, 1996). The waste that will be collected is exposed to rain, sun and winds before collection, which creates unhygienic conditions, which forms a risk to public health and causes pollution of the environment (Kassim and Ali, 2006). For Tanzania's second populated city, Mwanza, per capita waste generation in 2004 was even higher, e.g. 0.6-0.75 kilograms per capita per day (Mwanza City Council, 2004/2005). Expressed in methane emissions, it was reported that waste accounted for 5,7 percent of Tanzania's total GHG emissions in 1994 (UNFCCC, 2005).

Where the previous section noted most appropriate climatic conditions for biogas in South East Tanzania, map 4[21] demonstrates that cattle population per square kilometre is very low in these regions, which indicates low potential to feed bio digesters with agricultural wastes. However, with regard to improved dairy cattle the coastal area seems to have the highest potential in Tanzania (GoT, 2008c). When urban biomass is regarded, it can be stated that the two most populous cities of Tanzania, Dar es Salaam and Mwanza produce high

[21] Note: map displays indigenous cattle which are often non zero-grazing and therefore map 4 is valuable for the general picture but is of limited value to determine whether a region's manure production suffices biogas input requirements.

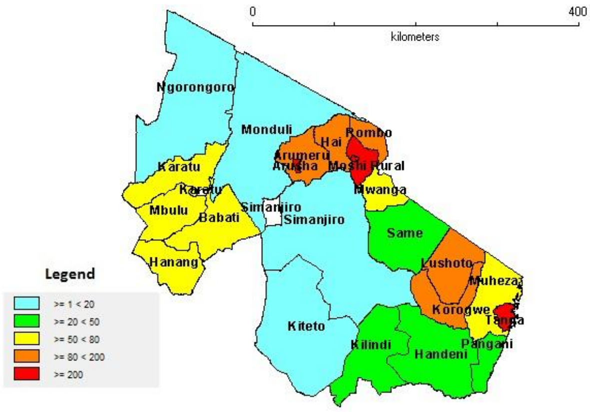
amounts of biodegradable wastes and are therefore considered suitable for biogas production from non-agricultural wastes.

3.2.4 Research Area - Need for Appropriate Renewable Energy

3.2.4.1 Demography

There is quite some difference in terms of population density within the study area, ranging from 2583 inhabitants per square kilometre in Arusha district to as little as 7 per square kilometre in Simanjiro district in Manyara (see figure 3.2). In correspondence with the low level of urbanisation nation-wide, in all research regions approximately 80 per cent of population lives in areas classified as rural, with slightly higher levels of urbanisation in Arusha region and around 90 per cent urbanisation level in Dar es Salaam. The levels of urbanisation per district are represented in figure 3.3.

Figure 3.2 Inhabitants per Square Kilometre



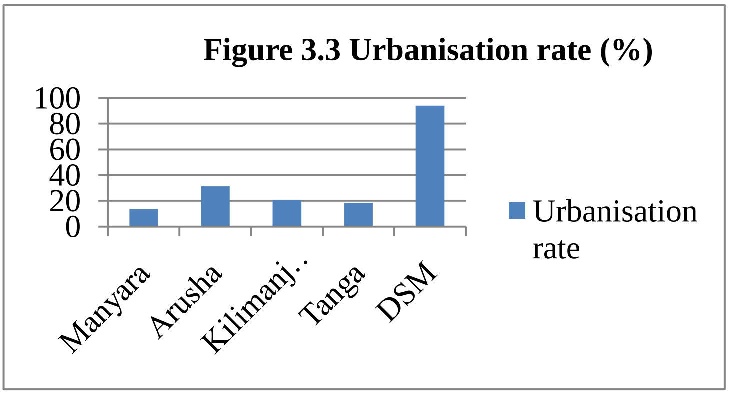


Figure 3.3 Urbanisation rate (%)

Source: Data from NBS (2009) **Source:** Data from Muzzini and Lindeboom (2008)

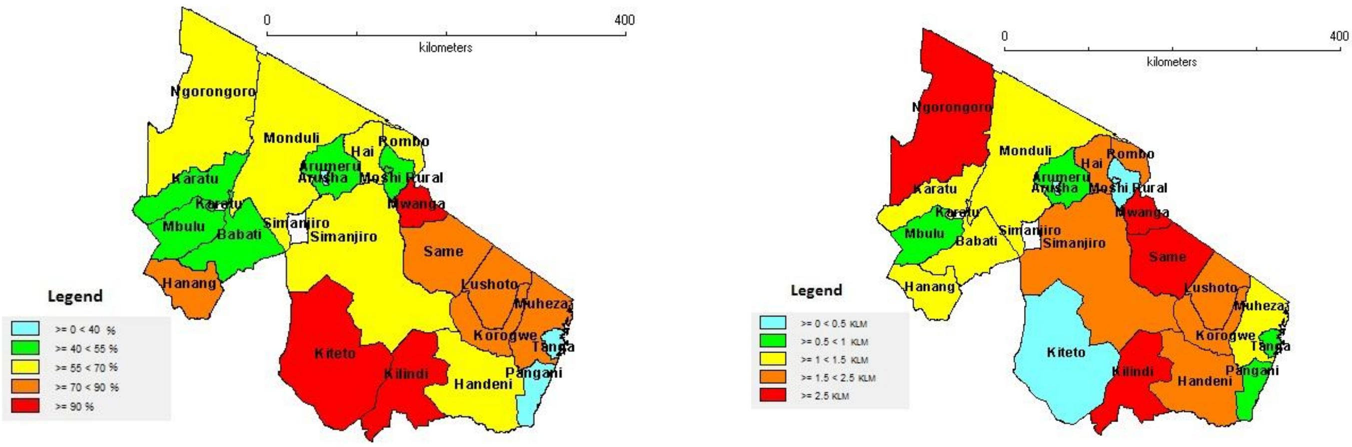
3.2.4.2 Household Energy Characteristics

Assessment of the primary source of energy used for cooking learns that in most districts 50-75 per cent of population relies primarily on firewood for cooking. In Mwanga, Kiteto and Kitindi districts over 90 per cent of households use predominantly firewood for cooking, as graphically represented in figure 3.4. Subsequently, figure 3.5 shows that the average time to collect firewood in the research area varies between less than 30 minutes in

Kiteto and Moshi rural districts; up to over 2,5 hours in Ngorogoro, Kitindi, Mwanga and Same districts (figure 3.5).

Although no figures could be retrieved regarding indoor air pollution and deforestation, three remarks regarding the need for appropriate energy technologies can be made given the high household reliance on firewood for cooking in most districts and long distance to firewood in some districts. First, high reliance on firewood for cooking is associated with health implications due to indoor air pollution. Secondly, the use of firewood for cooking implies the shrinking of forest cover and third, the labour-intensive collection of firewood, consumes a significant proportion of time. Therefore, it can be stated that, without sensitising for household socio-economic profiles, market potential exists for biogas in the research areas.

Figure 3.4 and 3.5 Households Using Firewood for Cooking and Distance to Firewood



Source: Data from NBS (2009)

3.2.5 Research Area – Is the Geographical Context Favourable to Produce Biogas?

3.2.5.1 Climatic Conditions

Figure 3.6 provides the average annual temperatures in the research areas based upon average temperatures registered for cities within the research area. Although figure 3.6 sensitizes for district temperatures, even within districts it is hard to generalize for 'average temperature' since elevation differences cause different average temperature depending on altitude. For instance, in Monduli district, the average temperature in the highlands is 20 degree Celsius, while the average temperature in the lower situated Rift Valley varies between 23 and 35 Celsius. Nevertheless, overall it can be stated that the biogas yields are likely to be higher in Dar es Salaam, Tanga and Moshi due to the favourable temperatures noted.

More important, as already noted in the assessment of national conditions for biogas; Northern regions in Tanzania suffer from erratic precipitation. Although figure 3.7 provides average annual precipitation in millimetres, the graph provides a distorted view. With the exception of Tanga region, all research regions have very low levels of precipitation in the months June, July, August and September, which can be as low as zero mm (Manyara region in August). Moreover, Monduli is classified as one of the driest districts in Tanzania, with annual precipitation below 500 mm in its lowlands (As an example, figure 3.8 depicts the monthly precipitation for Manyara region). Since biogas production requires constant water supply, the low levels of precipitation for a period up to four months in the Northern regions, is likely to be a constraint to generate energy from biomass. On the contrary, Tanga and DSM have favourable climatic conditions to produce energy from biomass due to stable precipitation and high temperatures.

Figure 3.6 Average Annual Temperature (C)

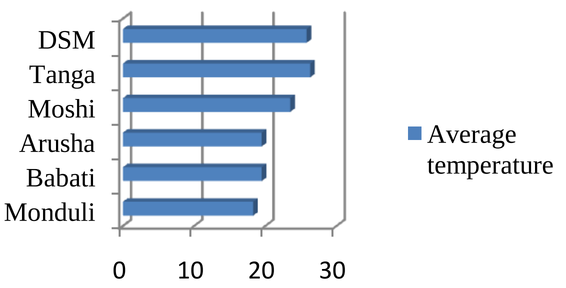
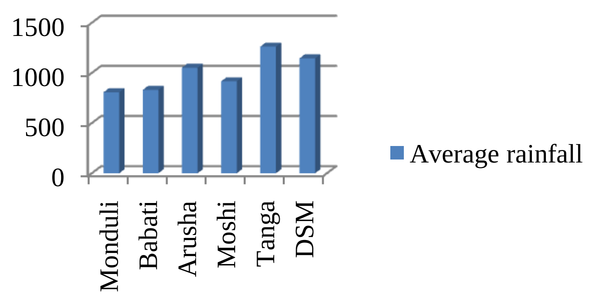
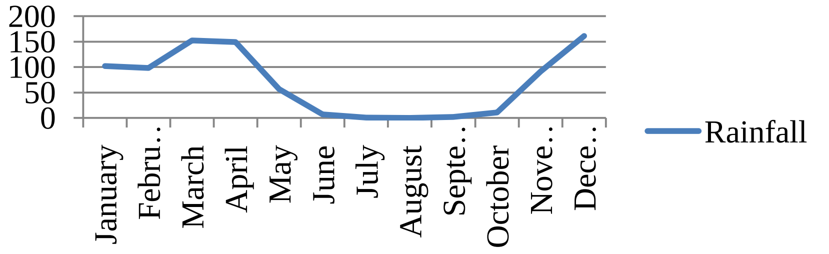


Figure 3.7 Average Annual Precipitation (mm)



Source: Figures 2 and 3 based on multiple data sources: EU Climate Data (2011); GoT (2008a, b); LeVoyageur (2011).

Figure 3.8 Monthly Precipitation Manyara Region (mm)



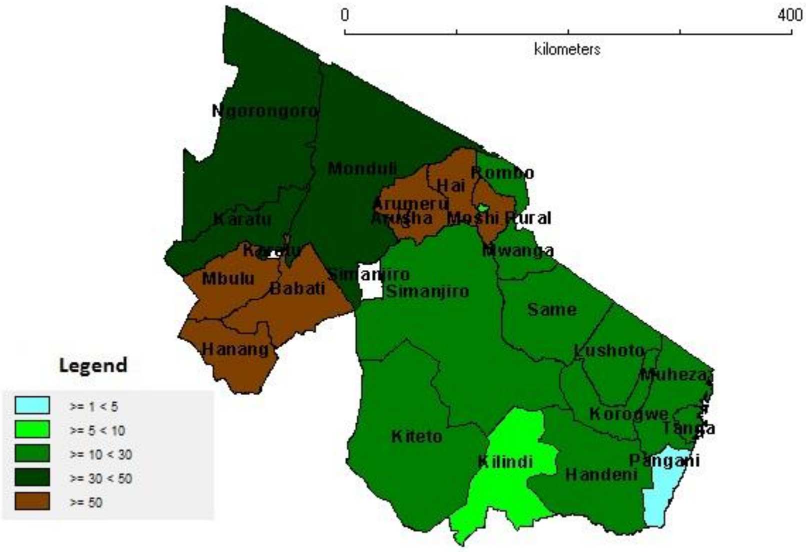
Source: Data from Le Voyageur (2011)

3.2.5.2 Available Biomass

The research area comprises approximately 20 per cent of Tanzania's 18,8 million cattle population, with over 1,5 million and almost 1,2 million cattle in Arusha region and Manyara region respectively (GoT, 2003c). Nevertheless, the lion share of all cattle is indigenous and belongs to pastoralists, which makes its value as proxy to determine whether sufficient input for biogas production is generated limited. It proves hard to generate reliable data regarding number of improved dairy cattle on district, regional and even national level in Tanzania. As mentioned, national improved dairy cattle population is estimated to be 400.000 (SNV, 2009). Of these, over 45.000 are in Tanga region (GoT, 2011) and it is indicated that a large dairy cattle population exists in Kilimanjaro region as well.

After all, available quantitative figures prove to be of limited value to assess whether the available biomass in the research area suffices the bio digester feeding requirements. At least indications exist that Tanga region and Kilimanjaro region have sufficient agricultural wastes available.

Figure 3.9 Cattle per Square Kilometre (x 1000)



Source: Data from GoT (2003c)

After assessment of the needs and potential of biogas in Northern Tanzania it can be stated that the need for appropriate energy technologies is in place; but that biogas might be of limited feasibility, with the exception of Tanga region and Dar es Salaam, based upon analysis of climatic conditions.

3.3 Assumptions

To recapitulate, chapter two provided a theoretical overview regarding favourable conditions to produce biogas and examined the prerequisites for energy technology cluster formation as well. Then, chapter three continued by an examination of the geographical conditions to generate energy from biogas based upon regional-, national-, and district level analyses. In this section, the accumulated knowledge is bundled and combined with relevant institutional-, enterprise-, and contextual dimensions in Tanzania and results in the formation of assumptions. These assumptions will provide directions for further assessment of biogas cluster formation processes in Tanzania.

3.3.1 Entrepreneurship Tanzania

Kristiansen (2001: 44) finds that several small-scale entrepreneurs emerge in Tanzania with creative business development ideas, Kinda and Loening (2010) estimate that at present

1.2 million rural non-farm enterprises exist in Tanzania. Non-farm business activities are perceived valuable in Tanzania since they reduce risks associated with farming losses due to erratic water conditions and droughts, e.g. non-farm activities are a source of income diversification (*ibid.*). In addition, Sunderam-Stukel, Deininger and Jin (2007) argue that households that run non-farm enterprises in rural Tanzania have income-levels about one-third higher than incomes of those without. Nevertheless, Tanzanian business start-ups are low (6 to 7 per cent annum), compared to other African countries, for instance business start-ups are 20 per cent in Kenya.

3.3.2 Institutional Dimension

The business initiatives that do take place, are mostly characterised as informal (Jin and Deininger, 2008; Kinda and Loening, 2010)[22]. Possible institutional-dimension explanations for the low number of small-business start-ups are lack of access to finance (Jin and Deininger, 2008) and high business registration fees (Kinda and Loening, 2010). In addition, Parawira (2009) states that no focused energy policy exists that supports biogas, that local government authorities are poorly informed and that there is no commercial infrastructure in Tanzania. Finally UN Tanzania (2010) mentions other institutional barriers as outdated legislation, fragmented administration at all levels between the centre and the local levels, lack of participation of various stakeholders in the management of the resources and poor resource databases and outdated and non existence of management plans for efficient resource use.

3.3.3 Entrepreneurial Dimension

Possible enterprise-dimension explanations for the low number of business start-ups are lack of access to information (Kristiansen, 2001) and weaker entrepreneurial spirit (Kinda and Loening, 2010; Kristiansen, 2001). The latter is defined as follows by Kristiansen (2001: 44): *"They are less risk-taking and able to save from consumption for investment and are more conservative, adhering to cultural and social traditions".* Kristiansen (2001:63) finds that information sharing among entrepreneurs is limited since networks of entrepreneurs are

[22] Only 14 per cent is formally registered (Kinda and Loening, 2010: 182). Similar findings are provided by Jin and Deininger (2008: 343), namely 18 per cent.

often limited to the immediate family, which forms a hindrance to assess information, capital and markets. In addition, Rogerson (2001: 117) explains that the majority of business start-ups in Tanzania are the result of 'enforced entrepreneurship', e.g. business start-ups in order to survive instead of driven by market opportunities. These 'enforced enterprises' are the least efficient and least remunerative of small enterprises since enforced entrepreneurs are often more copying than being truly innovative in their businesses (Arnold et al., 1994; Mead, 1998).

In general, the individual socio-economic benefits of schooling are represented by figures of the WB (2004a), which shows that Tanzanians who completed primary education earned 75 per cent more than people with no schooling did. People who completed secondary school earned even 163 per cent more. Specified to entrepreneurs, O'Riordan et al. (1997) find that Tanzanian entrepreneurs with post-primary education tend to establish enterprises that are more profitable. To increase entrepreneurial capacities, NGOs and donors provide Business Development Services (BDS) to stimulate entrepreneurship in Tanzania (Gibson, 1997).

3.3.4 Contextual Dimension

The financial internal rate of return (FIRR) for an investment in biogas is largely determined by the prices of the fuels that are being replaced (Mwakaje, 2008). Related to the existing energy consumption patterns in Tanzania, it can be seen that of the households using firewood, 80 per cent collected the energy carrier themselves (NBS, 2009). This figure has large consequences for determining whether an investment in an ARET can be earned back by replacing firewood. The costs of biogas digesters in Tanzania are close to €400[23], - (Voegeli et al., 2009; TDBP, 2011), which surpasses Tanzania's current GDP per capita of €308. Expressed to individual earnings, 75 per cent of employed people earned less than 100.000 TZS per month (approximately €45,-); while self-employed workers earned half of that. Employees of parastatals and central government earn the highest monthly incomes on average (GoT, 2009).

[23] The average household investment is €392 (TDBP, 2011)[23], while the payback period varies between 2,5 and 9,5 years, which depends on whether purchased charcoal or firewood, which is, as mentioned, largely collected free is substituted. In Tanzania, the ARTI system is sold for TZS 850.000 (euro 380), the energy source it replaces is generally charcoal and therefore the payback period is estimated to be around three years (Voegeli et al., 2009).

Despite the high investment costs, households can earn the investment back, provided that the biogas replaces earlier paid energy sources, commonly firewood or charcoal. For instance, in Rungwe district in Mbeya region it was shown that the consumption of firewood of households with a biogas plant decreased from 5.7 bundles to 1 bundle a week, and 5 litres of Kerosene a month was saved. By using the local price for firewood, calculations show that monthly savings accounted to 20,656 TZS (€9) on average for households buying their firewood (Mwakaje, 2008). Nevertheless, as mentioned, this only applies to 20 per cent of Tanzanian rural population. In another study, Voegeli et al. (2009) find that an average urban household using 1008 kg of charcoal per year can save one third of the charcoal (336) kg or an equivalent of TZS 276.000 (€ 124). In a study of the potential of biogas in Kenya, Jonušauskait (2010) finds that loan products for large investments in biogas installations might resolve the high upfront investment costs. Nevertheless, it requires the ability and willingness to save. In the same study, Jonušauskait (2010) proposes a form of leasing, e.g. a "pay for use" model which might offer a viable way around the large investment.

Besides the monetary aspect, the previous section identified the erratic precipitation in several regions within the research area, which implies limited constant water availability to feed bio digesters. The size of digesters provided ranges from 4, 6, 9 and 13 m^3. When fed minimal, the smallest bio digesters require 25 kg dung and 25 L water daily. The feeding of digesters increases to 100 kilograms dung and 100 litres water for the 13 m^3 digesters (SNV, 2009). It is likely that a household in rural areas, where hardly any precipitation is noted for the months June, July, August and September will be able to feed their bio digester with 25 litres water daily.

Accordingly, the following assumptions with respect to biogas sector development in Tanzania are formulated:

Assumption 1. Tanzanian biogas entrepreneurs face institutional constraints to start biogas enterprises.

Assumption 2. Most biogas entrepreneurs operate informal and take low business-risks.

Assumption 3. Biogas entrepreneurs who attended higher levels of education are more innovative and successful.

Assumption 4. High upfront investment costs and water scarcity hamper the dissemination of biogas technology.

3.4 Chapter Conclusion

This chapter introduced the regional-, national-, and local geographic and socio-economic context for the generation of energy from biomass. Subsequently, assumptions with respect to biogas cluster formation in Northern Tanzania were created. The next chapter presents the methodology of the present study.

4. METHODOLOGY

This chapter first presents the research objective, research questions and assumptions of the present study. Subsequently, the AEM will be introduced as well as the methods applied to measure the degree of biogas sector development in Tanzania. Thereafter, the research type and research methods will be presented, followed by the data gathering activities undertaken.

4.1 Research Objective and Research Questions

The aim of this study is fourfold. First, we intend to examine the present-day conditions to generate energy from biomass in Tanzania, as represented in chapter three. Secondly, we aim to assess the current state of the biogas sector in Tanzania. Thereby, the third aim is to generate a tool to assess the current state of the Tanzanian biogas sector, e.g. we propose an 'Appropriate Energy Model' (AEM). Fourth, future directions for biogas cluster formation in Tanzania will be identified.

Related to the aims of this study, the following two-fold main research question is developed:

1a. *"What are the conditions to generate energy from biomass in Tanzania?"*

1b. *"What strategies fit best for biogas cluster formation in Tanzania?"*

To answer these, three sub-questions need to be answered, first: *"What is the need and potential for biogas in Tanzania?"* Second: *"To what extent are institutional-, enterprise-, and contextual dimensions conducive to biogas sector development?"* Third: *"What are viable biogas business cases?"*

Moreover, based upon preliminary assessment of the characteristics for business development in Tanzania in general applied to biogas technology dissemination in particular, four assumptions were developed, to recapitulate:

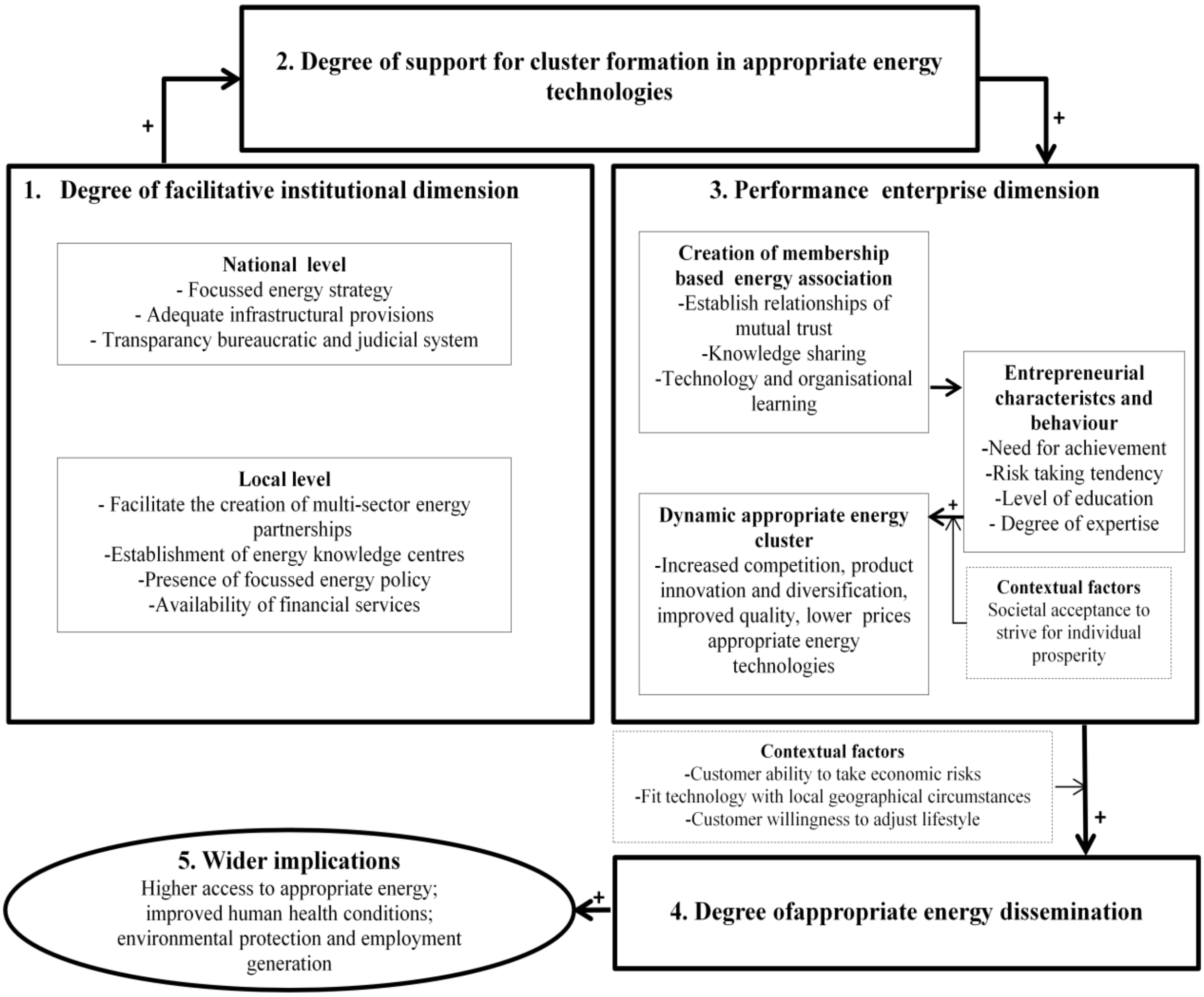
Assumption 1. Tanzanian biogas entrepreneurs face institutional constraints to start biogas enterprises.

Assumption 2. Most biogas entrepreneurs operate informal and take low business-risks.

Assumption 3. Biogas entrepreneurs who attended higher levels of education are more innovative and successful.

Assumption 4. High upfront investment costs and water scarcity hamper the dissemination of biogas technology.

Figure 4.1 Conceptual Model



4.2 Appropriate Energy Model

In chapter two, we examined the possibility to take a sector development model as point of departure and adjust it to become an appropriate tool for measuring the degree of appropriate energy cluster formation. Derived from that analysis we are confident to propose an Appropriate Energy Model, which consists of three dimensions: institutional-, enterprise-, and contextual dimensions. The three dimensions are subdivided in 8 constructs and subdivided into 18 indicators. The AEM mutates from the local capacity assessment model as proposed by Schoot Uiterkamp and Pennink (2011) in several ways. First, their 'team of recipients' dimension is not considered applicable to the present study since it is not one of the present aims to assess the impact of a capacity development intervention and thereby this dimension is not incorporated in the AEM. Second, additions to the original model were made at both institutional-, and enterprise dimensions. At the institutional dimension, the construct 'national institutional framework' is specified to become applicable to the appropriate energy sector. Further the indicators 'presence of focused energy policy' and 'availability and accessibility of financial services' were added to the 'local institutional framework' construct. Then, at the enterprise dimension, the first three constructs of the original model were specified to become applicable to the appropriate energy sector and a fourth construct 'entrepreneurial characteristics and behaviour' was added. Finally, the analysis in chapter two learned that the contextual dimension is highly relevant to determine the potential of newly introduced technologies. Therefore, the AEM consists of a 'contextual' dimension, which incorporates the constructs 'societal acceptance entrepreneurship' and 'degree of adoption introduced technology'. Table 4.1 presents the main criteria of the AEM.

Table 4.1 Appropriate Energy Model

Dimension	**Construct**	**Indicator**	**Cited in:**
Institutional	National institutional framework	Presence of focussed appropriate energy strategy, level of awareness raising, existence of preferential regulations, taxes and smart subsidies	Barry et al. (2011); Dollar et al. (2005); Kiplagat et al. (2011); Martinot et al. (2002); Nkya (2003); Parawira (2009); Sölvell et al. (2003); UN-Habitat (2011); Wang et al. (2010); Wolfe and Gertler (2004)
		Adequate infrastructural provisions	Dollar et al. (2005); Kristiansen (2001); Pike et al. (2008); Swinborn et al. (2006); Sölvell et al. (2003); Wolfe and Gertler (2004)
		Transparency bureaucratic and judicial system	Dollar et al. (2005); Kristiansen (2001)
	Local institutional framework	Creation of linkages between local energy enterprises, institutions and policy network	Dacin et al. (1997); Fromhold-Eisebith and Eisebith (2005); Helmsing (2001); Humphrey and Schmitz (2008); Oliveira (2008); Tvaronaviciene and Korsakiene (2007);
		Encouraging local energy business development by establishing knowledge centres and market facilitating organisations providing support for energy business start-ups	Audretsch et al. (2008); Banks et al. (2008); Dawson and Jeans (1997); Dollar et al. (2005); Goedhuys and Sleuwaegen (2000); Hartmann (2002); Martinot et al. (2002); Mead (1998); Melese and Helmsing

			(2010); Nkya (2003); Wang et al. (2010); WB (2011)
		Presence of focussed energy policy	Banks et al. (2008); Parawira (2009)
		Availability and accessibility of financial services	Audretsch et al. (2008); Dollar et al. (2005)
Enterprise	Energy clusters facilitating local learning	Creation of energy sector associations	Fromhold-Eisebith and Eisebidt (2005); Goldman (2005); Melese and Helmsing (2010)
		Establishment of agglomerations of local energy producers	Barr (1998); Fromhold-Eisebith and Eisebith (2005); Helmsing (2001); Humphrey and Schmitz (2008); McCormick (1996); Melese and Helmsing (2010); Westlund and Bolton (2003)
	Degree of technological and organisational capabilities	Energy innovations and product diversification	Ardichvili et al. (2003); Fritsch (2008); Goldman (2005); Kristiansen (2001); Melese and Helmsing (2010); Mwakaje (2008); Reuber and Fisher (2001); Woller (2004)
	Competitiveness of sector	New energy business development	Beer et al.(2003); Fritsch (2008); Goldman (2005)
		Creation of jobs in energy sector	Armstrong and Taylor (2000); Goldman (2005); Storper (1997); Woller (2004)
		Attracting external energy investment	WB (2011)
	Entrepreneur-ial characteristics and behaviour	Need for achievement, internal locus of control, risk-taking tendency, optimism, self-efficacy, creativity, task-related motivation, expertise/knowledge, expectations of economic/psychic benefits, entrepreneurial alertness	Ardichvili et al. (2003); Brockhaus (1982); Bull and Willard (2003); King and McGrath (1998); Wang et al. (2010)
Context	Societal acceptance entrepreneur-ship	Social norms in environment regarding value attached to strive for individual progress and prosperity	Dana (1993); Meek et al. (2010); Wang et al. (2010)
	Degree of adoption introduced technology	Upfront investment costs, ability to take economic risks, availability of alternatives, quality of technology	Ji-Qin and Nyns (1995); Martinot et al. (2002); Murphy (2001); Mwakaje (2008); Quadir et al. (1995); Szirmai (2005)
		Degree of energy fit with local geographical conditions	GTZ (2007); Marree and Nijboer (2007); Murphy (2001); Szirmai (2005)
		Perceived need, energy fit with values and ideology, willingness to adjust lifestyle, compatibility of technology with customer capabilities	Murphy (2001); Quadir et al. (1995)

4.3 Methods Applied to Assess the Biogas Sector Development

To assess the degree of biogas cluster formation in Northern Tanzania, a ranking system as developed by Berke and Conroy (2000) is applied to the Appropriate Energy Model. Berke and Conroy (2000) developed a ranking system in which the sustainability of greenways plan policies were ranked. In the traditional study of Berke and Conroy (2000), the greenways plans were ranked as "excellent (3)", "good (2)", "fair (1)" or "poor (0)" based upon how fully they addressed the indicators in favour of greenways. Similar evaluation techniques have been used in other studies (Brody, 2003; Brody, Carrasco and Highfield, 2006; Floress et al. 2009; and Schoot Uiterkamp, Azadi and Ho, 2011).

In this study, the scores per indicator will be represented by means of labelling "3", "2", "1", or "0". "3" is assigned when the indicator is met completely. "2" will be considered when the indicator is fulfilled largely. "1" will be regarded when there is attention for the indicator in the case-study context. "0" will be held when no, or few attention exist for the indicator. Taken together the rankings of the indicators per construct are ranked "excellent", "good", "fair" or "poor".

4.4 Mixed Case-Study

The present study draws on field research in Northern Tanzania, demarcated to Manyara, Arusha, Kilimanjaro and Tanga region and incorporates the economic capital Dar es Salaam as well. The field research of this study was conducted over a three-month period in 2011 in mostly Northern Tanzania. The research type is mixed quantitative and qualitative case study, based upon primary and secondary information. Yin (1994) summarizes the value of case- studies as study strategy as follows: *"Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources."* Eisenhardt and Graebner (2007) argue that theory-building strategies from case studies are deeply embedded in rich empirical data, which results in increased likelihood that theories are accurate, interesting and testable. Studies, which draw on a combination of quantitative and qualitative methods, have strong methodological power. As Hulme (2007: 14) states: "*A combination of quantitative and qualitative study methods can increase confidence in the reliability of the dataset and provide a richer dataset for explaining the processes underlying an outcome pattern*." Quantitative study methods are characterized as data collected by standardized questionnaires via survey methods, which come from a sampling frame. As such, quantitative analyses are indicated as being representative of a broader population. The main strength of the quantitative method is that the results deduced from the method allow generalizing findings for the broader population. Nevertheless, critics of the quantitative method argue that quantitative analyses sacrifices potentially useful information through process of aggregation and neglects intra-household processes and outcomes. Qualitative study methods on the contrary are characterized as narrative analyses, which provide in-depth insights on the meanings that actions have for people. Data is collected via – among others – conversations, semi-structured interviews, observations and focus group discussions. Despite providing in-depth knowledge on the impact of actions on people's lives, qualitative methods are often perceived *subjective* since it is hard to generalize findings (Hulme, 2007).[24]

Besides the methodological strength of combining quantitative and qualitative study methods, the practical application of the Q-squared study method is gaining ground recently in the field of development studies as well. This is due to increased consensus that combined study methods create more socially useful knowledge and can contribute to more effective policies as compared to single study methods (e.g. Hulme, 2007; Kanbur and Shaffer, 2006; White, 2002). In addition to the methodological power of Q-squared approaches and its increased practical application in study strategies, a combination of study methods adds to the *internal validity* of the study results as well. Gill and Johnsson (2002) labelled the strategy in which different methods are used to collect the necessary data to strengthen the internal validity of study results *triangulation.*

4.5 Data Gathering Process

In practical terms, quantitative methods applied in the present study are needs assessments and analyses of the biogas potential based upon household characteristics, geographical conditions, and available biomass. Data is retrieved from the 2007 Household Budget Survey of Tanzania's National Bureau of Statistics and additional data of regional governments, NGOs as well as the Food and Agriculture Organisation (FAO) of the United Nations. In addition, qualitative study methods in the form of open- and semi-structured interviews were used to gain improved insight in the underlying processes of the outcomes of

[24] For a comprehensive overview of strengths and weaknesses of both quantitative and qualitative methods and for enhanced insight in Q-squared study methods please refer to Hulme (2007).

quantitative analyses in order to to receive in-depth knowledge of the conditions to develop a biogas cluster in Northern Tanzania.

The challenge when adopting interviews as data gathering technique is to avoid subjectivity. Subjectivity is best mitigated by using numerous and highly knowledgeable informants who view the focal phenomenon from diverse perspectives. These informants can include organisational actors from different hierarchical levels, functional areas, groups, and geographies, as well as actors from other relevant organisations. It is unlikely that these varied informants will engage in convergent retrospective sense making (Eisenhardt and Graebner, 2007).

In sum, a total number of 70 interviews from different stakeholder groups have been conducted. The divide per stakeholder group is represented in table 4.3.

Table 4.3 Interviews Conducted

Stakeholder group	Sub-group	Number	Place
Public sector	National level	4	DSM
	Agencies	2	DSM, Arusha
	LGAs	6	Manyara, Tanga, Arusha, Kilimanjaro
Total		**12**	
Liaison	BDS providers (training + financial)	7	DSM, Manyara, Tanga, Arusha, Kilimanjaro
	Parastatal organizations	4	DSM, Arusha
	NGOs	3	DSM, Arusha, Manyara
	Dairy Cooperatives	2	Kilimanjaro, Tanga
	Distribution shops	7	Arusha, Manyara
Total		**23**	
Private sector	Solar, ICS, Biogas, Wind, Dairy	7	DSM, Arusha, Tanga
Total		**7**	
TDBP	Implementing partners/supervisors	8	Arusha, Manyara, Kilimanjaro, Tanga
	Customers	7	Arusha, Manyara, Tanga
	Masons	13	Arusha, Manyara, Kilimanjaro, Tanga
Total		**28**	
Total		**70**	

4.6 Chapter Conclusion

This chapter introduced the research objective and research questions; the AEM and research methods. The next chapter provides the assessment of the biogas sector in Northern Tanzania.

5. ASSESSMENT OF THE TANZANIAN BIOGAS SECTOR

This chapter provides the assessment of the biogas sector in Northern Tanzania. The presentation of the results is structured on the three dimensions and eight constructs of the AEM.

5.1 Institutional Dimension

5.1.1 National Institutional Framework

Appropriate energy strategy and regulations. The current national energy strategy dates from 2003, in which only limited attention is focused on appropriate renewable energy technologies to cater for rural energy needs. It is expected that in 2012 the next energy strategy will be ready, with more attention for renewable energy provisions. The increased governmental awareness for rural access to energy can be derived from the establishment of the 'Rural Energy Agency' (REA). Since 2005, REA functions as 'signpost to create awareness for rural energy' and implements policy of the Ministry of Energy and Minerals (MEM) to stimulate renewable energy development and dissemination in rural Tanzania. Their budget is considerable, since all electricity bills include a five per cent levy for rural energy, which flows via the MEM to REA. REA intends to stimulate private- and non-governmental sector actors to propose rural energy projects via public tenders. If selected, REA funds the rural energy project for 80 per cent. The current national government attention for rural energy provision is formulated as follows: *"There is a clear need for rural energy attention since the main priority of government policy is focused on commercial energy. Nevertheless, 90 per cent of population in rural areas depends on biomass as source of energy. The government acknowledges the discrepancy between current energy priorities and rural energy needs; therefore REA was established"* (Energy Officer, Rural Energy Agency, 14 April 2011).

Despite the potential of REA to provide rural energy access, their role is criticised by several stakeholders in the sector as being not knowledgeable and having limited attention for domestic energy needs. Instead, institutional grid-projects are favoured. Moreover, transparency of activities is limited, which results in that private-, and non-governmental actors are limited aware of rural tenders initiated by REA. The criticism is summarised by the following quotes of two stakeholders in the energy sector. First, "*All government attention is targeted at large institutional renewable energy projects which are not for domestic use, domestic renewable energy provision is a non-issue in Tanzania"* (Energy Advisor, SNV East

Africa, 5 April 2011). Second, "*REA only focuses on the electrification of cities in rural areas, not for domestic energy for rural areas"* (Director implementing partner TDBP, KAMA Monduli, 31 March 2011).

.

Besides limited interventions to cater for domestic energy needs, preferential taxes on input materials of bio digesters do not exist and it is unlikely that preferential taxes will be installed in the near future. As the renewable energy officer of the MEM states (12 April 2011) "*Cement is the most expensive material of bio digesters. We are trying to find how we can regulate this. We like to install tax exemptions but since cement is used for so many things it is hard to make it a tax exemption for only bio digesters."*

Although no preferential taxing for biogas exists, the GoT recently reduced the import tariffs of another renewable energy technology: solar pv installations. This led to increased market potential and the attraction of several international investors in solar.

Level of infrastructural provisions. Due to the geographic size dotted with hills and mountains in several districts within the research area, the road infrastructure is ill developed. On the national level, only 9 per cent (6808 km) of total roads (78891 km) are paved (Banks et al., 2008). Although road conditions do improve due to numerous large-scale road projects, these are mainly targeted at improvements of national connecting roads. Especially in rural areas road conditions are not well developed and vast areas are not accessible during rainy seasons, which results in higher costs for transportation and as such higher costs for doing business. The impact of the low accessibility of especially regional roads and the vast distances on the costs of biogas is formulated by one of the implementing partners of TDBP in Monduli District (31 March 2011): "*In some areas transportation costs almost double the price of input materials for bio-digesters."*

Transparency bureaucratic system. Procedures regarding business registration are far from transparent. At LGA level, all Cooperative- and Trade Officers re-direct entrepreneurs to the Business Registration and Licensing Agency (BRELA) in Dar es Salaam to register their business. Only after consultation of the CEO of BRELA in Dar es Salaam, it became clear that businesses operating at district level should receive a business license at the district government, which is mandatory and there is no need to travel to Dar es Salaam to register a business. In sum, a business license to operate at district level has to be acquired once, costs around 100.000 TZS (€45,-) and can be obtained at district government level. At BRELA, businesses can register their *business name*, which is not mandatory in Tanzania. As BRELA CEO explains (16 April 2011), "*Most people in Tanzania think that BRELA deals with business registration. This is not the case! BRELA deals with business names registration and having a business name is not obligatory in Tanzania.*"

5.1.2 Performance National Institutional Framework

Still limited actual action is undertaken to improve domestic access to modern energy technologies, but potential exists since increased governmental concerns with respect to domestic rural energy needs via the establishment of REA are noted and therefore we rate the first criterion of national institutional framework *fair*. The insufficient conditions of road infrastructure in rural areas imposes higher transportation costs of bio digester input materials, which subsequently increases customer prices for bio digesters in remote rural areas; since improvements are noted we rank adequate infrastructural provisions *fair*. The bureaucratic system to register a business (e.g. to obtain a business license) is even for local government officials a maze, which makes registering a small biogas enterprise in-transparent and therefore this criterion is ranked *poor*, which results in overall ranking for national institutional framework *fair* as depicted in table 6.1.

5.1.3 Local Institutional Framework

Creation of multi-sector biogas partnerships. Some private-, parastatal- and non-governmental sector cluster development initiatives do exist in the biogas sector but those often operate in a vacuum, at LGAs level there are no actions undertaken to unite individual initiatives to facilitate the establishment of multi-sector energy partnerships.

Establishment of knowledge centres to encourage local biogas business development. No local energy knowledge centres exist facilitated by LGAs. Nevertheless, LGAs do provide substantial business development support by forming local business groups around producers who wish to organise into cooperative societies (CS). Hereby a distinction is made between Income Generating Activity (IGA) Groups and Cooperative Societies (CS). The former are generally seen as an informal way to start to cooperate as a group, while after a maximum of three years the informal group has to transform into a formal CS. The current regulations state that specialised CS', in which biogas CS' would be categorised, require a minimum of 10 members, which is not supportive to accelerate biogas start-ups in sparsely populated district. Besides the general attention for cooperative formation and support at LGA level, little to no support is offered to individual entrepreneurs and there are no specific programs to facilitate the establishment of renewable energy clusters in general, and biogas clusters in particular. The value to register as a formal entity is phrased as follows: "*It is beneficial to register as a formal entity (CS/business) because formal registered entities are allowed to promote their products via advertisements, customers have more confidence in the products/services provided and a registration number is required to buy supply inputs"* (Community Development Officer, Babati District, 2 March 2011).

Private-, non-governmental and parastatal organisations are actively involved to encourage local business development in Northern Tanzania. There are many general business development services (BDS) offered to stimulate entrepreneurship by providing technical-, management-, financial-, and marketing support. In addition, the parastatal organisation Small Industries Development Organisation even provides loans and offers free location for small entrepreneurs from which to exploit businesses. Services of parastatals are subsidized but fees are charged, unless the national government states that a national interest is served by training a certain business group. Services provided by NGOs are often freely accessible.

Although only identified in one district, knowledge centres to support biogas entrepreneurs do exist in Northern Tanzania. The European Union via the Italian NGO Oikos even exploits two 'Community Energy Resource Centres' (CERCs) in Meru District. The CERCs deliver a range of services, which include the charging of mobile phones, sale of solar pv equipment, ICS and jatropha products. In addition, the CERCs serve as shop front for other ARETs such as biogas. Besides these direct services the shop can also serve as a foci point for all energy related issues, be it financial, policy wise or simply sharing information or seeking training on a certain product. Moreover, the CERCs in Meru District take care of administration and in-shop promotion of biogas for biogas masons. In return, the masons pay a service fee to the CERC. The functioning of the CERC is explained by the OIKOS project manager as follows (8 March 2011), "*The energy shops work closely together with local producers. The producers of for instance biogas plants, solar panels and ICS sign contracts with the energy shop. Doing so – the energy shops displays and markets products for local* *producers. Moreover, producers can use the energy shop as their office. Their administration is taken care of and a computer is available for the producers. To promote biogas, a biogas demo-plant is currently being installed next to one of the Energy shops. In return, around 10 per cent of sales revenues are paid to the energy shop, while 90 per cent of sales revenues are for local producers. The exact revenue partition is discussed per renewable energy technology. For instance, biogas masons pay 30.000 TZS per biogas plant sold to the energy shop. For a 6m2 biogas plant this means 30.000/200.000 = 15 per cent of total revenues. Solar producers pay 10 per cent for every item sold by the energy shop."*

Another interesting partnership was identified in Tanga region, as referred to in textbox 5.1.

Presence of focussed energy policy. The limited attention of local governments to facilitate business development and more specific to facilitate local appropriate energy business development corresponds with the absence of coherent policy to fulfil domestic energy needs. The following three quotes of stakeholders at the MEM, REA and SIDO underline the lack of local energy attention, first, *"There is no energy policy on district level, nor do district energy offices exist"* (Renewable Energy Officer, Ministry of Energy and Minerals, 12 April 2011). Secondly, *"The top-10 urgent matters at district government level do generally speaking not include domestic energy provision"* (Head Technology Development and Planning, SIDO, 13 April 2011) and third, *"No policies are developed at district level towards the dissemination of rural energy"* (Energy Officer, Rural Energy Agency, 14 April 2011).

Availability and accessibility of financial services. Formal financial- and microfinance institutions (MFIs) are present in Tanzania and typically provide loans against an 18-22 per cent interest rate per annum. Despite it, their financial services are often inaccessible for small enterprises and rural households due to lack of collateral. The loan-barrier is expressed as follows: "*Traditional MFIs are not interested in providing loans to small farmers in Tanga since they often do not have ownership of their land (lack of collateral) and if they do, the land is often not marketable"* (Director Farm Friends, Tanga District, 2 May 2011). In addition, the director of the Tanzanian Renewable Energy Association (TAREA) states (15 April 2011): "*Financial institutions require huge collaterals to get a loan for a digester;*

also other stiff requirements (such as preparing a memorandum) make access to finance problematic."

Alternative, better accessible loans are provided by Village Community Banks (VICOBAs) and Savings and Credit Cooperative Societies (SACCOS). VICOBAs are characterised as informal and typically available at village level, where members meet weekly. In several instances it was identified that VICOBAs offer loans to install bio digesters as well. Nevertheless, high interest rates of up to 21 percent in 8 months were identified as the following biogas loan-taker in Meru District exemplifies (30 March 2011): "*We had to pay an initial fee of 50.000 TZS and leant 700.000 TZS, which has to be paid back in 8 monthly instalments of 100.000 TZS each".* VICOBAs are weakly institutionalised and often a group of VICOBAs merges in a latter stadium into a more formalized SACCO's structure. In 2010, Tanzania counted 5344 SACCOS serving 560.000 members, typically providing loans against 2 per cent interest per month on declining balance. Before being able to receive loans, the potential member should pay a membership fee and take a share in the SACCOS, which is an investment of at least 100.000 TZS (€45). Despite its reach, costs to become member are high for people whose income is affected by seasonality, typically farmers. Besides the financial barrier to become member of SACCOS, previous experiences have resulted in limited trust in their reliability: "*The experience with SACCOS' is not good, since previously many people have lost their money when a SACCOS collapsed"* (Business consultant, Triodos Facet, 13 April 2011).

Besides the general availability of micro loans, two biogas-specific loans were encountered. In cooperation with TDBP, USAWA-SACCOS in Kilimanjaro region developed the 'eco-loan', while in Tanga region biogas loans are offered to members of the Tanga Dairy Cooperative Union. As the director of the USAWA-SACCOS in Moshi District explained (5 May 2011), "*We offer a special loan for renewable energy products, the eco-loan. It is in principle for all renewable energy technologies but is now exclusively used for solar pv products and bio digesters. TDBP delivers technical support and quality control of the bio digesters".*

Textbox 5.1 The Tanga Basket

The Tanga Dairy Cooperative Union (TDCU) is a Cooperative Society in Tanga region, which includes close to 5000 dairy farmers. The TDCU cooperates with milk processing firm Tanga Fresh, micro-finance institute Farm Friends and breeding company Holland Breeding. The Tanga Basket is a unique case of sector cooperation, which generates a win-win situation for all parties involved. Tanga Fresh guarantees TDCU farmers to buy all milk produced, if the quality is up to standard. The farmers receive loans from Farm Friends to be able to buy cows from Holland Breeding. The cows are a mixture of Frisian and Tanga cows, which results in increased milk production but still being resistant to the climate in Tanga region. The loan repayment does not stem from payments by farmers to Farm Friends but goes via TDCU. TDCU deducts the loan interest from the two-monthly milk payments to farmers. Via this cooperation, farmers increase their productive cattle, produce more milk and have higher earnings since Tanga Fresh buys all milk. Tanga Fresh benefits equally since higher volumes allow for increased market penetration and scale advantages, which are partially passed on to higher payments per litre to farmers. The TDCU farmers in one particular village of Tanga District, to be Pingoni, clearly addressed their energy issues to the board of TDCU in 2010. Their request was to receive help from TDCU to get biogas. TDCU, Tanga Fresh and Farm Friends discussed this request and Farm Friends decided to create a biogas-loan for farmers of TDCU. Since that time, approximately 30 biogas plants have been installed by masons trained by the TDBP in Pingoni. The 'biogas' farmers in Pingoni organized themselves in a biogas committee. The process in Pingoni is closely coordinated by a TDBP supervisor who holds weekly meetings with the biogas committee in Pingoni.

5.1.4 Performance Local Institutional Framework

Based upon lack of initiatives from local governments to establish multi-sector partnerships; the individual initiatives of NGOs, business consultants and parastatals to establish biogas clusters do not result in effective local energy clusters. On the contrary, the potential exists due to numerous initiatives, among which are energy knowledge centres and therefore we rate the first two criteria *poor* and *good* respectively. Based on the total absence of decentralised domestic energy policy, the criterion presence of focussed energy policy is ranked *poor*. Since financial services are widespread available, even in remote rural areas and specific biogas loans are initiated and are likely to be expanded, we assign the availability and accessibility of financial services *good*, which results in overall ranking of *fair* on the construct local institutional framework. The results of the institutional dimension are represented in part 1 of table 6.1.

5.2 Enterprise Dimension

5.2.1 Energy Clusters Facilitating Local Learning

Creation of biogas sector associations. In 2001, the Tanzania Solar Energy Association (TASEA) was established with the aim to promote the dissemination of solar energy in Tanzania. TASEA was transformed in August 2010 into the Tanzania Renewable Energy Association (TAREA). TAREA is a membership-based organization, which promotes appropriate energy use via political lobbying for policy development and to develop favourable tax tariffs to stimulate the dissemination of ARETs. Despite its recent transformation into a broader RE-association, TAREA is present in the sector, is engaged with numerous projects in solar, wind and biomass and has the potential to become a strong actor in the sector. Despite its potential, TAREA only employs 3 persons at present, so to become a strong actor in the RE-sector which lives up to its potential, TAREAs operational significance should be increased. Multiple stakeholders emphasised the need for proper quality of biogas installations, since quality determines the ultimate potential to be attractive for customers. The quality of bio digesters will be referred to in section 5.3, but TAREA might facilitate the establishment of national quality certification, which is deemed essential to create a successful biogas sector "*Creating a successful biogas sector requires national quality certification"* (CEO Tanga Fresh, Tanga District, 3 May 2011).

Establishment of agglomerations of local biogas producers. TDBP until now recruited and trained a pool of more than 500 masons mainly in Northern Tanzania. The recruitment was done on basis of masonry skills and experience. The level of organization and cooperation between masons is perceived loose in the research areas. Almost all masons work with an assistant, while others intend to cooperate. However, a core group exists in a certain area that focuses on biogas, though all masons interviewed have other masonry activities in mostly construction of dwellings. Despite the huge number of certified biogas masons trained, the productivity of the masons differs strongly and some have abandoned the technology completely since biogas plant construction alone is often too limited to make a sufficient income. This is explained by a drop-out biogas mason in Monduli District (16 March 2011):

"After negative experiences with customers who did not have the money to buy construction materials at once – which resulted in a very long construction process, I don't take new biogas constructing jobs. Employment in biogas is less attractive than the construction of houses since biogas promotion is time-consuming which limits the day of alternative employment while the actual installation only provides short-term employment."

The urban biogas model as utilized by ARTI is simple to install in three hours and ARTI did not train masons to specialize in the construction of these installations. Thereby, the ARTI model is most limited to dissemination in Dar es Salaam at present.

5.2.2 Performance Energy Clusters Facilitating Local Learning

The overall ranking of the construct energy clusters facilitating local learning is *good*, based upon the strong presence of membership-based organisation TAREA and the high number of certified local biogas producers.

5.2.3 Degree of Technological and Organisational Capacities

Biogas innovations and product diversification. In general, two biogas products currently exist in Tanzania, a rural type provided predominantly by TDBP and an urban model, disseminated by ARTI. Although the majority of population in the research area lives in rural areas, the need for urban digesters exists as well. As the ARTI director in Tanzania explained (14 April 2011): "*The energy needs (charcoal, firewood and LPG) in urban areas are higher and as such energy needs of urban citizens pose a threat to the forests in rural areas, whereby the rural population at first feels the scarcity of firewood for their energy consumption."*

Much diversification of both urban- and rural biogas digesters does not take place at present, and if they do, diversification is mainly top-down driven by NGOs in the sector. For instance, TDBP is currently involved in the creation of a rural biogas model applicable for pastoralists. Several smart options to diversify the biogas product were identified. For instance, the investment for building a proper toilet can easily amount to approximately 800.000 TZS (€358); a similar amount is required to install a bio digester. The construction of a bio digester can easily be combined with the construction of the toilet and connection to the biogas plant. In addition, improvement of sheds for cattle that can be connected to the biogas inlet can be targeted for extra assignments. In addition, the biogas plant needs a connection to the kitchen, which again offers new assignments. Moreover, it is common that households keep using firewood or charcoal after having a connection to biogas. In such a case the construction of an improved cooking stove is a good addition to the cooking opportunities available to the household; the combined installation of a bio digester and improved cooking stoves was observed in Monduli District and Meru District. At last, there is high demand for some appliances, for instance double burner stoves.

Stakeholders in public-, private-, and non-governmental sectors acknowledge that a high share of biogas masons lack the technical skills to provide good quality ARETs. These statements were observed during field research as well, were plenty bio digesters did not function properly due to gas leakages, as stated by one respondent: "*90 per cent of all biogas installations I controlled suffer from gas leakages"* (Former biogas entrepreneur and TDBP partner, Arusha District, 21 March 2011). In addition, the general business skills of biogas masons are perceived low. Potential entrepreneurs are limited interested to receive paid business development services as the following statement by an entrepreneurship trained of the Vocational Education Training Institute (VETA) underlines (12 April 2011): "*Most Tanzanians don't think they need entrepreneurship training to start-up a business and certainly don't want to pay for it. They always know someone who managed to set-up a business without taking a course in it."*

5.2.4 Performance Degree of Technological and Organisation Capabilities

Numerous options are identified for product diversification. Despite it, most options are not tapped yet, the technical- and business performance of biogas masons is often low, and therefore the construct degree of technological and organisational capabilities is assigned *poor*.

5.2.5 Competitiveness of Sector

New biogas business development. The initial product-development and first activities in the biogas sector were NGO-driven with TDBP being engaged with rural biogas dissemination and ARTI providing an urban biogas model. Some private offspring occurs in the biogas sector at present. Some entrepreneurs even argue that the presence of NGOs in the sector hamper the attractiveness for the private sector to step in since private sector actors cannot compete with the subsidies provided by NGOs to technicians and/or households. One of the reasons provided by REA for low business development in the biogas sector are high upfront investment costs in the technology while the market still has to be developed. We encountered one example of a TDBP-trained biogas mason who made it to become entrepreneur and referred to it in textbox 5.2. Although not included in the research area, it is worth noting since it was identified that this path from mason to entrepreneur is more exceptional instead of usual.

Creation of jobs in biogas. A considerable share of biogas adopters is employed in agriculture and as a result depends on agricultural revenues. In most research areas, the harvest season starts in July or August, which according to the fieldwork bares good market demand to December and especially in November and December. Specifics of the harvest differ per year and within the research area. After the harvest season the demand start to be very slow. The approximate monthly income of masons during the high demand months is 400.000 TZS (€180) with peaks to 700.000 TZS (€313), while during the low season months masons generate around 100.000 to 200.000 TZS. (€67) to no income. Accordingly, the seasonality plays a large role in the potential biogas employment. Consequently, most biogas masons in all research areas see the construction of biogas installations mainly as side-activity since biogas does not offer sufficient job opportunities year-round. Biogas masons typically find alternative employment in the construction of houses or in agriculture.

Attracting external biogas investment. The biogas sector does attract external investment, of both public- and private organizations. Besides the NGO supported TDBP and ARTI, two international enterprises plan to enter the Tanzanian biogas sector, e.g. Shambatech and SimGas. Both will target the urban biogas market first.

Textbox 5.2 From Biogas Mason to Entrepreneur

Alex is an entrepreneur active in Songea in the Southern region of Ruvuma. Originally, a VICOBA was implementing the biogas technology in the area; however as relations between the far-off coordinating TDBP worsened the cooperation ended. Consequently, Alex started his own registered biogas company, AB Biogas. The company currently employs six masons and hires six assistant technicians. Alex says he needs to build 10 plants a month to keep his company financially sound. While he can reach this number in the months of May and June when harvest is boasting demand, other months are more difficult. Alex is doing advertisement through radio to raise awareness and sales. However, he finds that he lacks organization skills for running the business. Besides market potential, he has had trouble in registration, finding credit and attracting educated personnel.

5.2.6 Performance Competiveness of Sector

Based upon the low number of local biogas business start-ups, we rate the first criterion of the construct competitiveness of sector *poor*. Although affected by seasonality, the criterion creation of jobs is assigned *good*, since the installation of bio digesters is highly profitable in the peak months and by far exceeds Tanzania's GDP per capita of €308. Due to the attraction of two private enterprises that will provide biogas technology in Tanzania, the criterion attracting external investment is rated *good*, resulting in overall ranking for competitiveness of sector *good.*

5.2.7 Entrepreneurial Characteristics and Behaviour

Need for achievement and risk-taking tendency. Our study results suggest that there is a clear distinction in entrepreneurial potential between –often low educated– technicians and educated –visionary, pro-active– entrepreneurs. Moreover, masons with higher age and experience also expressed more interest to formalise business activities. As a former biogas entrepreneur in Arusha District states (21 March 2011): *Biogas masons have the wrong* *attitude, they think: "if the assistance of the donor program stops, I will return to old business"*.

A passive, risk-avoidance attitude was often encountered under masons. In interviews with masons about starting a company the responsibility of having employees, possibly a loan and other fixed monthly costs was considered a huge hurdle. Other risks that are seen as important obstacles are the need to hire employees, which cannot necessarily be trusted. Most of the interviewees prefer to be employed themselves. The masons perceive the risks for starting a business in general too high. The lion share of the group sees opportunities for increasing their income in other ways. Moreover, they do not see the potential perish of the programme as a threat to their activities, since there is a belief in the long-term involvement of all kinds of donors. Some of the masons' attitudes are captured in textbox 5.3. In addition, many studies regarding entrepreneurship in Tanzania indicate as barrier the lack of finance to start an enterprise. Most stakeholders interviewed do not agree with this popular vision. As a VETA-entrepreneurship trainer states (12 April 2011): "*Small enterprises in the past had a lot of trouble to get access to finance from money lending institutes. With the arrival of MFIs, SACCOS and VICOBAs, this situation changed for the better recently. In addition, even banks such as Barclays and NMB are offering credit to small-scale entrepreneurs nowadays. Despite it, the problem remains that entrepreneurs don't know that the situation to get finance has improved."*

Some stakeholders interviewed explained the lack of risk-taking tendency by limited skills to set-up a business of typically low-educated masons: "*The level of education of masons is low; masons don't see the added value of forming a business and probably don't have the skills to set-up a business"* (Implementing Partner TDBP, FIDE Manyara Region, 2 March 2011).

Textbox 5.3 Biogas Mason Attitudes Captured

"I would prefer to work in a formal registered business. The business can do the promotion and marketing, which makes it easy to get new assignments. With some other masons I discussed forming a business but we don't have a clue how to start, none of us can write a business plan, which is necessary to register and get access to finance" (Individually operating young TDBP biogas mason, Arusha District, 23 February 2011).

"Being a TDBP-biogas mason is good since TDBP brings sufficient clients and the organization pays well…..there is no need to organize ourselves in a registered business since TDBP is here at least till 2013" (Two young TDBP biogas masons, Arusha District, 23 February 2011).

"I would like to work in a small enterprise, as long as I don't get the responsibility of being the owner. I already discussed with other masons the opportunity of setting-up a company, without results, we did not find a solution" (Middle –aged TDBP biogas mason, Meru District, 30 March 2011).

"I would like to register as a formal biogas business; therefore I need support from TDBP to register, for marketing assistance, information about annual tax payments and information about how to obtain a business license which allows doing business in other districts as well" (Middle aged biogas mason, Meru District, 4 March 2011).

"Money is the main barrier to start an enterprise.....I don't want a loan since I don't like loans. I was once involved with a SACCOS called Pride. However, I quitted because they demanded too much attention and it caused stress" (TDBP biogas mason, Meru District, 30 March 2011).

5.2.8 Performance Entrepreneurial Characteristics and Behaviour

We rate the construct entrepreneurial characteristics and behaviour of biogas masons in Tanzania *poor* since motivation, need for achievement and levels of education and expertise are low. The enterprise level performance is depicted in part 2 of table 6.1.

5.3 Contextual Dimension

5.3.1 Societal acceptance entrepreneurship

Acceptance by social environment to strive for individual progress and prosperity. Several national and international stakeholders in the Tanzanian biogas argue that entrepreneurship has low societal status. Moreover, it happens that customers believe that providing energy is a service, which should be provided free by the government. In some instances entrepreneurs are hardly trusted, since they "only want to make money" according to customers, as a former biogas entrepreneur in Arusha District states (21 March 2011): "*Entrepreneurship is not valued by society, working in-office or for the government has higher status.*"

Moreover, the low value attached to entrepreneurship has implications for the labour force in the business sector as well, as articulated by the CEO of Tanga Fresh (3 May 2011): "*NGOs attract many educated local people, which form a barrier to entrepreneurship. Work in a private company and do hands-on work gives low societal status. Working for NGOs is preferred since it provides more societal status, the work is more convenient and the financial benefits are higher.*"

The limited value attached to strive for individual progress might partially be explained by reference to the *ujamaa* philosophy which prevailed for almost 30 years in Tanzania, as expressed by a VETA-entrepreneurship trainer (12 April 2011): "*Earlier government policies and laws never allowed citizens to do business and thereby business skills were not obtained. Then, due to SAPs Tanzania moved from state-led to market-led economy. This caused a shift whereby individuals needed business skills to fulfil their needs. These skills were never stimulated, so not in place. Some people nowadays start seeing the benefit of obtaining entrepreneurship skills to make money in the market economy. This is a positive aspect but is moving slowly.*"

Nevertheless, the spokesperson of a TDBP-Implementing Partner, the Evangelical Lutheran Church Tanzania, states that also local cultures within Tanzania to a large extend determine whether doing business will be appreciated (21 March 2011): "*Even pastors in the North can have a shop, whereas in the South this is not happening.*"

5.3.2 Performance Societal Acceptance Entrepreneurship

We rate the construct societal acceptance to strive for individual progress and prosperity *fair*, since earlier forms of socialism might explain to a certain extend a low level of acceptance to strive for individual progress, but this acceptance gradually increases and several ethnic groups in Northern Tanzania have a strong business attitude.

5.3.3 Degree of Adoption Introduced Technology

Customer profile, degree of upfront investment costs and quality. The majority of biogas customers are relatively wealthy. About half of them have a fixed income and are employed as teacher, pastor, nurse, businessperson or work for the government. From various field visits, it was derived that in general their houses are well maintained. The other half of the biogas customers is involved in agricultural activities and their financial situation is therefore affected by seasonality, with high earnings in the second half of the year. Textbox 5.4 captures the biogas customer profile. Most biogas customers interviewed consider economic arguments more important than ecological preservation. The customers mainly substitute LPG, electricity and firewood. A pattern identified are the low construction of biogas for agricultural customers in seasons of drought, were incomes are generally low and for all customers, limited biogas installations being installed in the months December and January since in these months private school fees are due.

Biogas stakeholders identify the high upfront cost for bio digesters a barrier to structural disseminate the technology in Tanzania. To address the cost-issue, ARTI developed a leasing structure, which is labelled 'gas for cash', whereby urban customers lease a bio digester and save money without having to carry the burden of high upfront investment costs. The concept is explained in textbox 5.5. Finally, the quality of biogas digesters is a serious issue. Both urban and rural bio digester models cause malfunctioning. As mentioned, this is partly explained by technical omissions, which occur due to human installation failure. It has been widely acknowledged among all biogas stakeholders in the research area that to make biogas attractive for potential customers, quality should be up-to-standard. See textbox 5.6. This is especially so, since people rely to a large extend on word-of-mouth promotion. Nevertheless, another source of malfunctioning is inappropriate handling by customers via for instance inappropriate feeding of digesters: "*At present, if technical occur with the bio digesters, the problem is mostly not feeding by customers. It takes almost one month to start producing gas, so when fed inappropriate, the plant does not function optimally"* (Director ARTI, 14 April 2011).

Degree of biogas fit with local geographical conditions. The previous section acknowledged technical problems with bio digesters due to limited feeding by customers, which is partially caused by limited potential to feed bio digesters due to a limited fit of the technology with geographical conditions in the research area. In some instances, a too large digester was installed to be fed with available (semi-) zero grazing livestock. For the urban bio digester variant most waste collected from bars and restaurants is used, in combination with households own waste. If demand for biogas increases; contracts will be signed with waste disposal belts. In addition, as already noted in the geographical context chapter, stable access to water indeed hampers the functionality of bio digesters installed in certain districts. In the months June, July, August and September for the research areas, Dar es Salaam and Tanga excluded, have limited precipitation. The consequences on the functioning of bio digesters are explained by the following two situations:

"In the past 3 years, 7 biogas installations have been installed in Ol Doiny Sambu ward, out of which only one functions up to standard at present. Particular problems in Ol Doiny Sambu ward are related to underfeeding of installations. The area faces extreme droughts and is mountainous. Because of this, food for cows consists mostly exclusively of grass. Households have limited resources available to feed additional concentrates for all cows. This results in low amounts of cow dung to feed the biogas plants. In addition, since the primary water source available is water from the mountains –which is very cold –the digestion process within the digester is not optimal" (Quality supervisor TDBP, Ward in Meru District, 8 March 2011).

"…the drought in several areas is a problem. Many areas do not have sufficient rainfall to mix the cow manure with, therefore biogas installations do not work properly; sometimes bio digesters are not fed with water for over three days" (Experienced former CAMARTEC-biogas mason, Arusha District, 24 February 2011).

TDBP mentioned in the biogas programme implementation document (SNV, 2009) to address the water scarcity via improved stables to collect urine and via the installation of water harvesting systems. Nonetheless, the field visits showed that stables to collect urine are mostly not improved, whereby urine collection is improper, which implies limited ability to overcome water scarcity. Secondly, water-harvesting installations were identified at one site in Monduli, one of the driest districts in Tanzania. In Monduli district, the installation of a water harvesting system implies an additional investment of 300.000 TZS (€134); which poses a 35 per cent investment increase for a typical rural biogas installation. The Small Industries Development Organisation (SIDO) further suggested linking up with district water user groups (WUGs) to effectively combine bio digesters with water harvesting systems (Head Technology and Planning, 13 April 2011). In Tanga region and Dar es Salaam, drought is less problematic due to stable annual precipitation. Besides the negative influence of periods of drought from June to October as a climate barrier to the functioning of bio digesters, from a technical perspective, the months March, April and May are considered less appropriate for construction of biogas plants because the rainy season impedes any digging. Digging is an important prerequisite before a bio digester can be installed.

Subsequently, the distances between places have been referred to shortly in the examination of the national institutional framework already. The interviews and observation during field research identified two patterns, first: due to large distances between places, the costs for input materials like cement and plumbing are often high due to transportation. Secondly, even sparsely populated districts have cement available, while plumbing materials need to be obtained in district-, or even regional capitals. Nevertheless, despite the availability of these materials, their costs are high due to limited quantities required by district population. One of the implementing partners of TDBP in Monduli District formulates it as follows (31 March 2011): "*All materials are locally available but still most materials are bought in Arusha city since the lower prices for materials in Arusha offset the transportation costs from Arusha to Monduli since locally bought materials are very expensive*".

Perceived need and fit with values and ideology. To some extent, cultural resistance against use of human excreta in rural bio digesters was noted since a fair amount of population does not want to handle human excreta, and in general, some do not want to handle waste at all. The perceived need for biogas in general is low, people adhere to traditional cooking traditions and low awareness for the technology exists. For instance, the Maasai ethnic group does not appreciate cooking with gas, but rather use roasting of meat. Furthermore, most families, which possess cows, are pastoralists and usually stay for periods up to two years in a given location. It is unlikely that these families will invest in expensive bio digesters.

Textbox 5.4 The Biogas Customer Profile Captured

"Most customers are the well-off citizens" (ARTI director, 14 April 2011).

"From 1000 biogas plants installed in 2010, only 30-40 of them were financed by financial institutions" (Biogas Advisor, SNV Tanzania, 1 March 2011).

"At first, we promoted biogas as an environment saving technology. However, most potential customers raised their eyebrows when they heard this argument. Since then, the economic argument prevails" (Director, ARTI, 14 April 2011).

"Biogas customers often live in remote rural areas which makes quality supervision, promotion and after sales service expensive due to high transportation costs" (Former biogas entrepreneur, Arusha District, 21 March 2011).

"Most customers are agrarians, who have their harvest season in June, July and Augustus. Agrarians have money the second half of the year and therefore sales of bio digesters are expected to increase" (Implementing Partner TDBP Monduli District, KAMA, 31 March 2011).

Textbox 5.5 Leasing Biogas?

ARTI launched a daughter enterprise, namely ARTI Energy Development. ARTI Energy Development created a leasing framework. Households are targeted and asked: "Do you pay every month 50.000 TZS or more for charcoal?" If yes, ARTI offers to install a biogas installation, feed and maintain it, where the gas can be used by the households. The digester remains property of ARTI Energy. The household benefits by a 30.000 per month saving for charcoal and pays ARTI 10.000 per month. ARTI calls it: "gas for cash". ARTI expects this concept to be beneficial if in a given street numerous households can be convinced to take a biogas digester. Hereby quality control, maintenance and costs to feed digesters are low and social pressure is exercised on the people responsible to feed the plant by all customers in the street (Director, ARTI, 14

Textbox 5.6 Relationship between Quality and Demand

"Good quality of biogas digesters is the key promotion tool for the dissemination of biogas. Bad quality results in negative word-of-mouth which discourages other potential customers" (TDBP Supervisor, Tanga District, 3 May 2011).

"...every bad operating biogas plant is the worst advertisement you can think about" (Former biogas entrepreneur, Arusha District, 21 March 2011).

"Quality should be inherently related to business development by showing biogas masons that poor quality is a bad marketing strategy and vice versa" (Business Consultant, Triodos Facet, 13 April 2011).

5.3.4 Performance Degree of Adoption Introduced Technology

The early adopters of biogas technology in Tanzania are the well-off citizens, which are generally able to take economic risks. The upfront investment costs of bio digesters impede further dissemination of the technology to lower income groups, the majority of population. Nevertheless, since the potential exists to do increase access to urban bio digesters via smart leasing solutions, the first criterion of the construct degree of adoption introduced technology is assigned *fair*. The biogas technology has limited fit with climatic and geographical conditions in Manyara, Arusha and Kilimanjaro regions due to erratic precipitation and almost no precipitation from June to October. To some extent, the limited fit can be catered for by installation of improved sheds and water harvesting systems to collect urine and water respectively. In sum, climatic conditions for biogas in Tanga region and Dar es Salaam are favourable and unfavourable in Manyara, Arusha and Kilimanjaro regions. In the latter regions, adjustments to mitigate the effects of erratic precipitation pose significant extra costs which results in their actual installation being limited. After all, we assign the indicator degree of fit with local geographical circumstances *fair.* Some evidences suggest that rural biogas technology is rejected based on cultural norms, existing cooking habits and that perceived need is low among pastoralists. On the contrary, no structural indications exist that these factors will impede further dissemination of biogas and therefore the rate the criterion perceived need and fit with values and ideology *fair,* which results in overall ranking of *fair* on the construct degree of adoption introduced technology. After all, the performance on contextual dimension is depicted in part 3 of table 6.1.

5.4 Chapter Conclusion

The assessment of the biogas sector in Northern Tanzania at three dimensions and 8 constructs demonstrates that Northern Tanzania scores “Poor” on two out of four constructs at the enterprise dimension, to be ‘degree of technological and organisational capabilities’ and ‘entrepreneurial characteristics and behaviour’. Five constructs are rated “Fair” and the remaining construct, ‘energy clusters facilitating local learning’ is rated “Good”. The analysis of the results follows in the next chapter.

6. WHAT IS THE POTENTIAL TO ESTABLISH A THRIVING BIOGAS CLUSTER?

Based upon the assessment of the biogas sector in Northern Tanzania in the previous chapter, this chapter provides analysis of the results in chapter 6.1 and results in the creation of figure 6.1 'State of the Biogas Sector'. The second part of this chapter, section 6.2, consists of discussion in which the set assumptions are discussed based upon findings of the present study.

6.1 Analysis of Results

Table 6.1 depicts the status of the biogas sector in the research area at institutional-, enterprise-, and contextual dimensions. In this section, we present analysis of the results at the three dimensions and accompanying 8 constructs.

Table 6.1 The Biogas Sector Assessed: Research Area

Dimension	**Construct**	**Specific composition**	**Perfor-mance**
Institutional	National institutional framework	Presence of focussed appropriate energy strategy, level of awareness raising, existence of preferential regulations, taxes and smart subsidies	**1**
		Adequate infrastructural provisions	**1**
		Transparency bureaucratic and judicial system	**0**
	Overall score of the construct		**Fair**
	Local institutional framework	Creation of linkages between local biogas enterprises, institutions and policy network	**0**
		Encouraging local biogas business development by establishing knowledge centres and market facilitating organisations providing support for energy business start-ups	**2**
		Presence of focussed energy policy	**0**
		Availability and accessibility of financial services	**2**
	Overall score of the construct		**Fair**
Enterprise	Energy clusters facilitating local learning	Creation of biogas sector associations	**2**
		Establishment of agglomerations of local biogas producers	**2**
	Overall score of the construct		**Good**
	Degree of technological and organisational capabilities	Biogas innovations and product diversification	**0**
	Overall score of the		**Poor**

	construct		
	Competitiveness of sector	New biogas business development	**0**
		Creation of jobs in biogas	**2**
		Attracting external biogas investment	**2**
	Overall score of the construct		**Fair**
	Entrepreneurial characteristics and behaviour	Need for achievement, internal locus of control, risk-taking tendency, optimism, self-efficacy, creativity, task-related motivation, expertise/knowledge, expectations of economic/psychic benefits, entrepreneurial alertness	**0**
	Overall score of the construct		**Poor**
Context	Societal acceptance entrepreneurship	Social norms in environment regarding value attached to strive for individual progress and prosperity	**1**
	Overall score of the construct		**Fair**
	Degree of adoption introduced technology	Upfront investment costs, ability to take economic risks, availability of alternatives, quality of technology	**1**
		Degree of biogas fit with local geographical conditions	**1**
		Perceived need, biogas fit with values and ideology, willingness to adjust lifestyle, compatibility of biogas with customer capabilities	**1**
	Overall score of the construct		**Fair**

6.1.1 Institutional Dimension

The national institutional framework is of limited support to stimulate appropriate energy entrepreneurship in biogas. Although a national renewable energy strategy is expected, it is not in place yet, which makes the national bureaucratic system in-transparent for private-, non-governmental-, and even local public sectors involved in the Tanzanian energy sector. In combination with the absence of preferential biogas taxes, the present status quo is likely to miss-out on potential appropriate energy initiatives initiated in Northern Tanzania. For instance, much is unknown how private-and non-governmental actors can benefit from REA as signpost in the sector. Regardless of limited specific energy action undertaken by national- and district-level government, technicians and producers can count on support to establish (in-) formal cooperative societies. Nevertheless, cooperative societies seem to be of limited value for rural biogas masons since the minimum number of members should be ten, while demand for biogas is insufficient to organise as cooperative societies in sparsely populated districts. Alternatively, a business license can be obtained at district level; nevertheless, the bureaucratic system is not facilitative for biogas business start-ups.

Despite the absence of national-, and district level governments support, non-governmental and parastal organisations fill to some extend the gap by providing business development services to potential-, or already existing biogas entrepreneurs. For instance, TDBP trained 500 biogas masons and SIDO provides office space for technicians in renewable energy who would like to become entrepreneur. Moreover, in one district two donor-funded rural energy centres are created. These energy centres support renewable energy entrepreneurs and function as shop front to create awareness among rural populations for appropriate energy technologies.

6.1.2 Enterprise Dimension

The establishment of an energy sector association in combination with a vast base of biogas-trained masons provides potential to create a biogas cluster. Since chapter two identified the presence of skilled labour force as one important prerequisite to attain cluster formation. Nevertheless, two out of four constructs are assigned ‘poor’. Biogas masons rarely identify business opportunities via innovations and product diversification. In addition, biogas masons in Northern Tanzania demonstrate a low risk-taking tendency. To exemplify, plenty diversification options for the biogas product exist such as installing cow sheds, toilet connection to bio digesters and the installation of water harvesting system, but are rarely unleashed by masons. Overall, biogas masons see the construction of bio digesters mainly as side-activity. Almost no initiatives of biogas masons exist to start-up small biogas enterprises.

We identify three possible explanations for the low business start-ups and risk-taking behaviour. First, some empirical findings suggest that low level of education and risk-avoidance impedes business start-ups by biogas masons, whereby age and experience positively moderate the intention to start an enterprise but not so much the actual establishment of one. However, an alternative, third explanation could be low profitability to establish biogas enterprises at present due to latent demand. For instance, demand and consequently profitability to install bio digesters is affected by seasonality and thus unstable. Potential customers have low incomes in the first half of the calendar year, while the second half of the year is attractive with monthly incomes up to the average annual GDP per capita.

Nevertheless, around December/ January potential customers also invest in education of children when annual (private) school fees are due. Demand is likely to be positively affected if partnerships with dairy cooperative unions are established. Moreover, if more rural energy centres are created, partnerships with these institutions will likely to yield benefits due to increased access to customers and no business skills needed since energy centres take care of the business side.

When the urban sub-market is considered, it is likely that competition increases in the short-run. Where the first initiatives to disseminate both urban and rural biogas models were donor-funded, two private biogas providers will enter the Tanzanian biogas urban sub-market shortly. Besides higher competition at the urban biogas sub-market, a creative lease-construction of biogas is offered in Dar es Salaam since recently. This lease construction limits customer upfront investment costs and is thereby likely to boost urban biogas demand.

After all, the enterprise dimension is positively affected by the presence of a sector association and higher competition and increased product affordability at the urban biogas sub-market. The rural biogas sub-market is positively affected by partnerships with dairy cooperatives and with rural energy centres, if these will be established at larger scales. The enterprise dimension is negatively affected by limited profitability due to unstable demand and biogas technicians with limited business skills.

6.1.3 Contextual Dimension

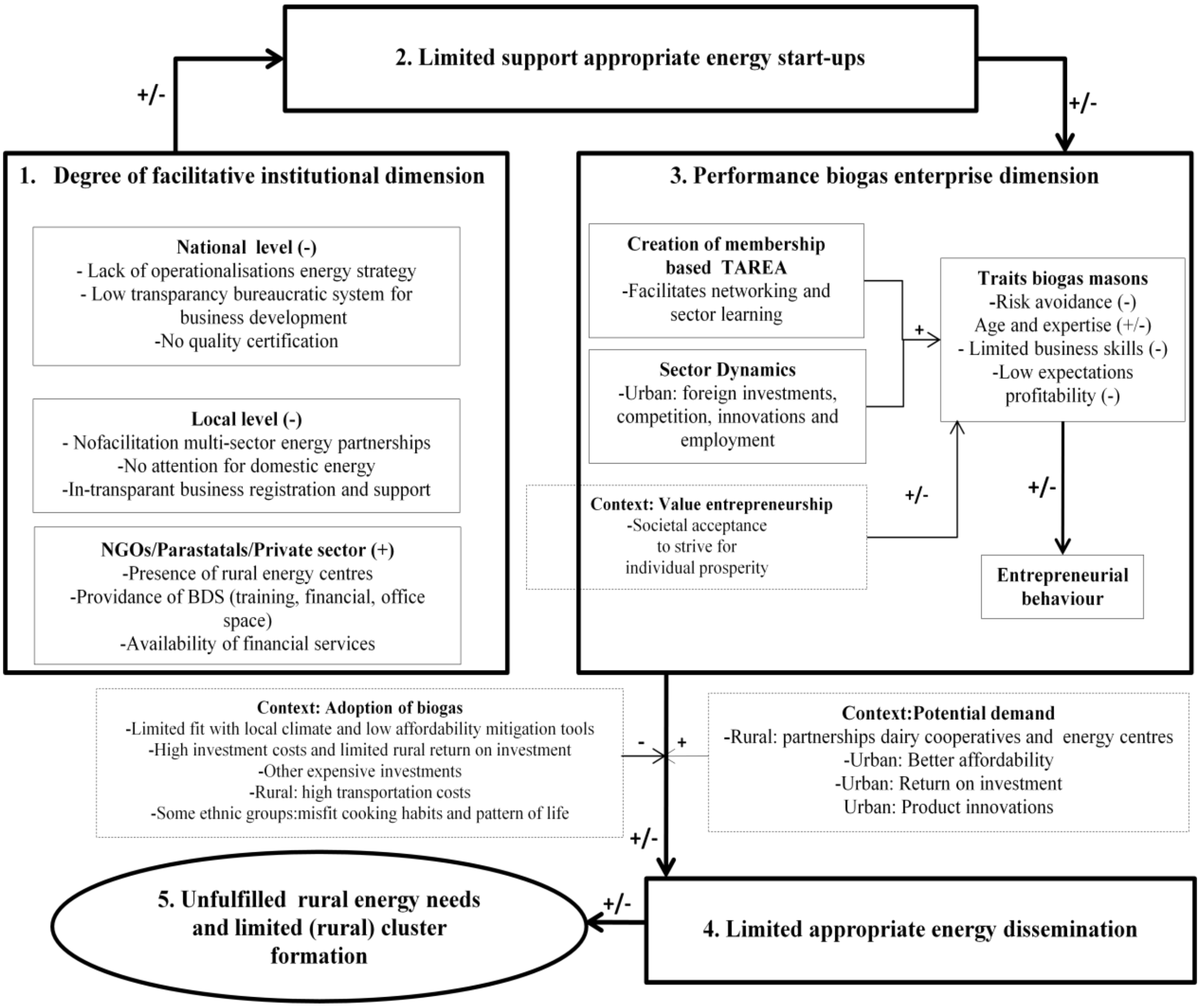
Some indicators suggest a limited acceptance of entrepreneurship in the Tanzanian social context. Thereby, this contextual dimension might be of influence on the passive, risk-avoidant attitude of biogas masons as well. With respect to customer profiles, biogas is a typical 'early-adopter' appropriate energy provision in Tanzania, which is only affordable for well-off urban residents and farmers who possess at least 2-3 cows, which reflects their relative affluence. The previous section identified partnerships with dairy cooperative unions as positively stimulating rural biogas demand. Nevertheless, most cattle are indigenous and belong to pastoralists, who are unlikely to invest in biogas due to their mobile way of life. In addition, since farmers often live in sparsely populated rural areas, transportation costs of input materials is high. Cooperation of biogas masons with dairy cooperatives is identified as viable to lower transportation costs and quality control per digester since a cluster of customers is targeted. Nevertheless, perceived need is relatively low for rural population since the majority collects firewood free. In urban areas, needs are higher since biogas replaces charcoal. Some ethnic groups have a negative attitude towards biogas since they reject handling of manure and human excretion, or their cooking traditions have a misfit with the gas provided through bio digesters.

Limited functionality of bio digesters hampers structural dissemination of the technology in villages and among members of dairy cooperatives at present, whereby a strong reliance on 'word-of-mouth' via for instance speeches in the church is noticed. Functionality is partially related to installation omissions, but geographical and climatic conditions impede the functionality of bio digesters in several parts of Northern Tanzania, heavy showers during March, April and May and drought from June until October. Expensive mitigation tools such as improved cowsheds and water harvesting systems are rarely installed. On the contrary, the climate conditions are optimal in coastal Tanga region and Dar es Salaam.

6.1.4 Outcome: State of the Biogas Sector

In sum, the analysis of the results deviates in several aspects from the preferred relationships as identified in figure 4.1: conceptual model. We find that the institutional dimension is of low support to start biogas businesses, while non-governmental and parastatal organisations provide try to encourage business development via business development services. Translated to the enterprise dimension it is found that the business development services offered and the creation of a membership based energy association do not result in a thriving biogas sector so far. Nevertheless, some dynamics exist in the urban biogas sub-market due to increased competition and creative investment-cost reductions. Lower dynamics are identified in the rural sub-market. The lower rural dynamics are best explained since at least partially impeding social norms-, economic-, geographic-, and cultural contextual dimensions exist. After all, when the current conditions are regarded, a relative low potential for large-scale dissemination of the biogas technology in rural Northern Tanzania exists. The opportunity to establish a flourishing innovative and competitive biogas cluster is limited due to constraints at institutional-, enterprise-, and contextual dimensions. The analysis of the institutional-, enterprise-, and contextual dimensions of the biogas sector in Northern Tanzania is graphically represented in figure 6.1.

Figure 6.1 State of the Biogas Sector



6.2 Discussion

The previous section structurally analysed the results as derived from the biogas sector assessment in Northern Tanzania and identified underlying relationships. The present section intends to discuss the results via comparison of the assumptions set in the theoretical framework with the study-outcomes.

6.2.1 Assumptions

The results give evidence to accept assumptions 1, 2 and 4, while we reject assumption 3. The explanation is provided below.

Assumption 1. Our study shows that the complex web of governmental bureaucracy and limited transparency in Northern Tanzania hinders energy business development. Moreover, no energy policy or favourable appropriate subsidies or taxes for biogas entrepreneurs exist. This leads us to accept assumption 1: Tanzanian biogas entrepreneurs face institutional constraints to start-up biogas enterprises. Our results and analysis argued that the absence of clear government directions impedes the creation of a facilitative infrastructure for energy entrepreneurs. Breschi and Malerba (2001: 823) forcefully endorse this finding. They state that government policies can play a very important role in cluster formation via accommodating new firms, investments in education and the provision of support infrastructures. A possible explanation for the low action at district government level to facilitate energy entrepreneurship might be their relatively low autonomy from central government, although government authorities' responsibilities are decentralised. For instance, UN Habitat (2010) figures show that budgets of municipalities depended for 89.9 per cent on national government flows in 2005/2006. In addition, it was stated that due to central government control, local authorities lack real power and act in many cases only as implementation agents of national governments (*ibid*).

To sum up, the national- and district government authorities are not much involved in developing specific strategies to address energy needs of the urban and rural poor and to facilitate biogas entrepreneurship. Nevertheless, institutional support is required in the biogas sector since the sector is still in its infancy. In these situations, Hartmann (2002) suggests that public 'top-down' cluster interventions are required since these cover a broader, more diversified portfolio of activities, including location marketing, labour qualifications and have wider regional economic impacts. At present, non-governmental organisations provide general business development services, while especially TDBP provides a wide portfolio of assistance to develop the biogas sector. However, it is likely that one day the assistance will stop, and if the government does not provide institutional support at that moment, the potential of the biogas sector is limited. As Banks et al. (2008:2) formulate the risks of non-governmental support: *"Many rural energy projects have a good initial start up period, while supported by international funders, and 'expert' technical assistance. However, over time, the level of innovation, management and skilled resources available to manage and support the project drops off, simply because the projects are too small to sustainably employ highly skilled staff".*

However, there also might be some barriers at the enterprise dimension to active cooperate with governments. As Nauwelaers (2001: 106) states that top-down initiated clusters often have more difficulties to raise active participation of target organizations due to 'the atmosphere of mistrust between public and private actors that often prevails in regions'. Barriers to attendance might exist due to feelings of remoteness, of cultural distance and of not really being concerned (Newlands, 2003).

Assumption 2. We find that substantial emphasis is placed via all sorts of BDS on knowledge creation of (potential) entrepreneurs in biogas, to capacitate them to innovate and –to a lesser extend- financial services are provided to them. However, so far, this has not resulted in a vast entrepreneurial base in biogas and most biogas masons work individual, informal and do not take business risks. Therefore, assumption 2, 'most biogas entrepreneurs operate informal and take low business risk' is accepted. The limited impact of business development services on biogas entrepreneurship is explained by Rogerson (2001) and Saini and Bhatia (1996) who that the impact of business development services to stimulate entrepreneurial activity is limited. In addition, Audretsch et al. (2008) mention that providing business development services might not be sufficient to stimulate entrepreneurship. Governments should actually support entrepreneurship to navigate the bureaucratic system to start new businesses; support in finding money and provide support when entrepreneurs have problems.

Assumption 3. The level of education of biogas masons is often limited to primary school level and our study results demonstrate that the path from biogas mason to biogas entrepreneur is seldom taken in Tanzania. This is despite the fact that TDBP emphasises the need to establish biogas enterprises in their biogas-training course. Regardless of education, we find that expertise, e.g. age and time in masonry do have an impact on the desire to become entrepreneur. Nevertheless, older masons are not necessarily more innovative and successful than others, since most of them do not establish a biogas enterprise. Therefore, our study identified that training often uneducated biogas masons to become entrepreneur might not be viable. Since there are hardly any biogas entrepreneurs in Northern Tanzania, we reject assumption 3: biogas entrepreneurs who attended higher levels of education are more innovative and successful. This finding is in contrast with a number of studies, which point at a relationship between level of education/ expertise and entrepreneurship; as incorporated in the 'entrepreneurial characteristics and behaviour' construct of the AEM. Our finding that level of experience is facilitative to being proactive is confirmed by Bull and Willard (1995), who state that experience determines the willingness to innovate, take risk and be proactive.

Assumption 4. This study finds that demand for biogas in general is still in its infancy due to high upfront investment costs and a vast entrepreneurial base is missing. Only a small number of well-off early adopters can afford biogas installations at present. Moreover, we find that geographical circumstances e.g. periods of drought and extreme precipitation limit the potential of bio digesters. Therefore, we accept assumption 4: high upfront investment costs and water scarcity hamper the dissemination of biogas technology.

This is not to say that biogas cluster formation does not occur at all in Tanzania, as referred to in the previous section. In general, climatic conditions to produce biogas are more favourable along Tanzania's East coast, in Tanga region and in Dar es Salaam due to stable precipitation and a warm climate. In particular, urban areas are characterised with some cluster formation dynamics in the biogas sector: entering of the market by foreign investors and creative lease-constructions are likely to thrive urban biogas competition. This pattern of investing in urban areas is explained via insights in the 'economics of innovation'. These theories argue that innovations are likely to cluster in geographical areas where specialised inputs, services and resources are concentrated which are necessary for the effective working of innovative processes (Breschi and Malerba, 2001: 818). Applied to our study, we find that the water-input for biogas is favourable in Dar es Salaam. Moreover, services are clustered in this economic capital of Tanzania and potential customers possess more financial resources since Dar es Salaam hosts many government officials who, as identified in chapter three, earn high incomes and Dar es Salaam host many enterprises, which results in a geographic 'clustering' of potential customers. Together with the establishment of a membership-based energy association, it is well possible that the formation of a biogas cluster in Tanzania has its roots in Dar es Salaam.

6.2.2 Limitations

Several limitations apply to this study as well. Due to time constraints and limited financial resources, this study is conducted in a time-span of three months and only in Northern Tanzania. Moreover, this study did not incorporate non-biogas adopters. Thereby, the study only relied on third-person interview-data when cultural perceptions of ethnic groups and way of life of pastoralists were regarded.

6.3 Chapter Conclusion

In this chapter, we first provided analysis of the results, which led to identification of a pattern of relationships, which is presented in figure 6.1. Furthermore, we discussed the state of the biogas sector development in Tanzania. Hereby, the findings of this study were linked to the cluster formation debate. At last, limitations of the study were provided. The next chapter provides conclusion and recommendations.

7. BIOGAS IN TANZANIA: FROM AMBITIONS TO REALITY

This chapter presents the answer on the two-fold main research question, which is derived from answering the three sub-questions. Subsequently, the second part provides a discussion of the research process, the results, and limitations. Finally, modest recommendations are given on the way forward in the biogas sub sector.

7.1 Conclusion

7.1.1 Objectives and Contribution

The objective of this study was fourfold. First, the conditions to generate energy from biomass in Tanzania were examined. Second and third, the Tanzanian biogas sector was assessed by creating and using the 'Appropriate Energy Model' (AEM). Fourth, based on the outcomes, future directions for biogas sector development have been provided. The strength of this study is that by applying economic and geographical perspectives, valuable insights are generated beyond the economic perspective. This study demonstrated that contextual dimensions for a large part determine what the impact of energy interventions *will* be and can be predicted for by combining these fields. Moreover, the strength of the AEM is its value for academics, governments and NGOs. Of academic value since it brings the current debate of what energy strategies are appropriate to address multiple targets in developing countries, e.g. energy provision, waste management, health improvements, agricultural productivity, job creation and reductions in GHG reductions to a higher level. It brings the discussion of what is needed to a level where empirical insight is generated in institutional-, enterprise-, and contextual dimensions, which facilitate or hamper the practical implications of theoretical discussions. Of practical value since governments and NGOs are able to acquire knowledge of the points for improvements in their (appropriate) energy programs.

7.1.2 Results

The results showed that the Tanzanian national government initiates formal structures to address rural energy needs, but lack the effective translation into district government initiatives to formulate and implement appropriate energy directives; nor is local action undertaken by district governments to create fruitful cooperation between stakeholders in the energy sector. The lack of governmental action hampers the formation of biogas clusters. The results also provide evidence that a vast amount of financial- and business development-services are provided by (international-) NGOs, donors and parastatals to technicians to become entrepreneur. Nonetheless, these efforts do not result in a large number of biogas enterprise start-ups. Third, a small group early adopters who possess the financial means to be able to afford the expensive technology, so far only adopt biogas. Regardless of the limited economic viability, the establishment of structural cooperation with dairy cooperatives and the development of creative leasing models are identified to target a wider biogas customer base in a given geographical context, which reduces costs of quality supervision and transportation per customer and allow buying input materials in larger quantities. Thereby, the urban biogas model seems to be economic viable due to shorter payback periods since urban biogas mainly substitutes the more expensive charcoal for cooking. Rural biogas on the contrary, mainly substitutes free firewood. As a result, the dynamics of demand and supply are likely to focus on urban biogas, while the domestic energy needs are equally high, if not higher in rural areas.

7.1.3 Plea to Address *Rural* Energy Needs

As mentioned, the dynamics of demand and supply steer the biogas sector in Tanzania towards urban areas. Nevertheless, options do exist to create potential to form biogas clusters in rural areas as well, if contextual dimensions as climate, available biomass and cultural conditions are favourable. In practical terms, the creation of energy centres in sparsely populated districts is identified as appropriate to fulfil rural energy needs but is likely to have limited commercial viability. Nonetheless, if the Tanzanian government is serious about the energy needs and health of rural people; it could be suggested that, in consultation with membership based energy organization TAREA, the REA and LGAs might finance the establishment of certain centres and provide support to energy entrepreneurs in this sense. Alongside partnerships with dairy cooperatives, energy centres might be able to connect biogas masons, who possess limited business mentality, with a customer base and thereby reduce costs per customer.

Despite all efforts, a sense of reality should be in order. Although biogas is presented in academic literature as most appropriate to fulfil local energy needs, address waste management issues and accompanying lowers carbon emissions; numerous geographical, climatic, economical and social considerations are identified which form obstacles for current 'large-scale small-scale' biogas dissemination in Tanzania. It is unlikely that the current national rural biogas programme in Tanzania, will contribute much to the size of the energy problem in Tanzania and therefore more initiatives are required. As SNV's biogas advisor for East Africa states (5 April 2011): "*Tanzania's national biogas project is a hobby project"*.

To address the domestic energy needs in Tanzania, a sole focus on biogas might not suffice, be of substantial value to improve cooking associated health and prevent deforestation for cooking needs to take place. At the time being, a focus on more affordable 'sustainable' energy technologies might be more viable to address the plea for appropriate energy in distant rural areas. Hereby, well available and low-cost improved cooking stoves are deemed to have higher impact on daily live for the urban and rural poor, since economic and geographical barriers are not applicable to these more efficient burning tools.

After all, it is concluded that a joint effort of public-, private-, and non-governmental sectors in identifying and stimulating better access to a mix of appropriate energy technologies for the urban and rural poor citizens of Tanzania is required to structural address prevailing energy needs-, improve indoor air conditions and halt the rapid deforestation.

After all, as Murphy (2001: 175) righteous claims: "*The main objective of energy projects should be to improve rural people's quality of life, not to disseminate a particular technology or mitigate an environmental problem"*

7.1.4 Methodological Limitations

Some remarks could also be drawn with respect to methodology and the AEM. The research was mixed quantitative-qualitative case study, although mixed; most information regarding the status of the biogas sector used qualitative analyses. As a result, it is hard to generalise the findings of the study. The results could be too narrow to draw conclusions on the potential of biogas technology in other African countries. Especially with reference to the contextual dimension of the AEM, even generalizing for other parts of Tanzania is restricted. The results thereby serve as propositions and can be used in further quantitative research including a larger sample of African countries. Thus, the reliability might be limited that could be improved in future studies.

7.2 Recommendations for Further Research

A glimpse of biogas cluster formation potential is identified by the introduction of bio digesters which can be leased instead of bought, which makes the economic barrier to obtain the energy lower technology lower. In addition, the introduction of private actors Shambatech and SimGas on the Tanzanian domestic biogas market might bring more competing products, higher innovations and better fit with local climatic and geographical circumstances due to smart innovations. The actual impact of higher affordability of biogas and more competition on biogas cluster formation should be studied in further research. Its value is that a future study might provide an opening to a better understanding of energy technology cluster formation in African societies. Secondly, further research is welcomed to study the concept and practical considerations to establish rural energy centres especially in relation to the mentioned strategy of clustering and delivering an appropriate energy mix to households in rural areas. Since the aim of the study was to make a first attempt to produce a model in which the appropriate energy sector in countries can be assessed, the model should serve as a starting point for other scholars in order to revise and extend it where needed.

Epilogue

"*Yesterday morning for the last time I walked through the old Islamic centre of Dar es Salaam. In my search for a local newspaper to bring onboard, I passed desperate grannies, people with leprosies and a begging child, crying it out loud. Waste, human excreta and mud, all in the scene of a rainy day...tears in my eyes"*

(Letter to Christien: flight Dar es Salaam – Düsseldorf, 6 June 2011)

It was just an optimistic oriented rich Westerner, who past by as an outsider and observed the lives of people of flesh and blood, brothers and sisters, 'who didn't quite made it', to any human standards. He felt miserable. Till weeks after he was in a state of sorrow and tried to get things straight in his mind: "Basic needs", "Human capital", "Enlightenment", "MDGs", the confusion lasted. It was not the feeling he hoped to bring home when he packed his backpack, four months ago. It was the best experience he could get.

Only in the calendar year 2011, around 80 passionate, ambitious International Development Studies' students from Utrecht University complete or completed their master thesis. They definitely wrote a page or two full recommendations to improve current development projects or to initiate new ones, just as I did. What a potential since Utrecht is just *that* small spot on the world map. The majority of them will continue in some way in the field of development: in NGOs, social business', in 'corporate social responsibility' projects, in fair trade, at government levels, at large multilateral organisations, in journalism and others in academia. Whatever the future brings, it is good from time to time to take a deep breath, stand still and question yourself: "*What am I doing, what do I really value and how can I contribute, as small as it is?"*

That being said, the final words of this thesis are meant for consideration:

"If there is love, there is hope to have real families, real brotherhood, real equanimity, and real peace. If the love within your mind is lost, if you continue to see other beings as enemies, then no matter how much knowledge or education you have, no matter how material progress is made, only suffering and confusion will ensue."

-H.H. the XIV Dalai Lama-

REFERENCES

Articles and Books

Akubue, A. 2000. Appropriate Technology for Socioeconomic Development in Third World Countries. **The Journal of Technology Studies**, Vol. 26, No. 1, pp. 33-43.

Allison, M., Harris, P.J.C., Hofny-Collins, A.H. and Stevens, W. A review of the use of urban waste in peri-urban interface production systems in: Allison, Harris, Hofny-Collins and Stevens (eds.), ***DFID NRSP Publication***, (Coventry: The Henry Doubleday Research Association, 1996).

Ardichvili, A., Cardozo, R. and Ray, S. 2003. A theory of entrepreneurial opportunity identification and development. ***Journal of Business Venturing,*** Vol. 18, pp. 105-123.

Armstrong, H. and Taylor, J. in: Armstrong and Taylor (eds.), ***Regional Economics and Policy, 3rd edition,*** (Oxford: Blackwell, 2000).

Arnold, J.E.M., Liedholm, C., Mead, D. and Townson, I.M. 1994. Structure and growth of small enterprises in the forest sector in Southern and Eastern Africa. ***Paper No. 47, University of Oxford,*** pp.

Asomani-Boateng, R. and Haight, M. 1999. Reusing organic solid waste in urban farming in African cities: a challenge for urban planners. ***Third World Planning Review***, Vol. 21, No. 4, pp. 411-428.

Audretsch, D.B., Bönte, W. and Keilbach, M. 2008. Entrepreneurship capital and its impact on knowledge diffusion and economic performance. ***Journal of Business Venturing,*** Vol. 23, pp. 687-698.

Bailis, R., Ezzati, M., Kammen, D.M. 2005. Mortality and greenhouse gas impacts of biomass and petroleum energy futures in Africa. ***Science,*** Vol. 308, pp. 98-103.

Banks, D., Clark, A., Steel, K., Purcell, C. and Bates, J. Integrated rural energy utilities – a review of literature and opportunities for the establishment of an IREU in: Banks et al. (eds.), ***Renewable Energy and Energy Efficient Partnership,*** (Rondebosch: RESTIO Energy Pty Ltd, 2008).

Barr, A. 1998. Do SMEs network for growth? ***Centre for African Studies, University of Edinburgh,*** Paper presented at the conference enterprise in Africa: Between poverty and growth.

Barry, M.L., Steyn, H. and Brent, A. 2011. Selection of renewable energy technologies for

Africa: Eight case studies in Rwanda, Tanzania and Malawi. ***Renewable Energy,*** Vol. 36, pp. 2845-2852.

Barton, J.R., Issaias, I. and Stentiford, E.I. 2008. Carbon-Making the right choice for waste management in developing countries. ***Waste Management,*** Vol. 28, pp. 690-698.

Beer, A., Haughton, G. and Maude, A. in: Beer, Haughton and Maude (eds.), ***Developing Locally: An International Comparison of Local and Regional Economic Development,*** (Bristol: Policy Press, 2003).

Berke, P.R. and Conroy, M.M. 2000. Are we planning for sustainable development? An evaluation of 30 comprehensive plans. ***Journal of the American Planning Association***, Vol. 66, pp. 21–33.

Brody, S.D. 2003. Examining the effects of biodiversity on the ability of local plans to manage ecological systems. ***Journal of Environmental Planning and Management,*** Vol. 46, pp. 817–837.

Brody, S.D., Carrasco, V. and Highfield, W. 2006. Measuring the adoption of local prawl: reduction planning policies in Florida. ***Journal of Planning Education and Research***, Vol. 25, pp. 294–310.

Bogner, J. and Matthews, E. 2003. Global methane emissions from landfills: New methodology and annual estimates 1980-1996. ***Global Biochemical Cycles,*** Vol. 17, pp. 1065-1083.

Bogner, J., Pipatti, R., Hashimoto, R., Diaz, C., Mareckova, K., Diaz, L., Kjeldsen, P.S., Faaij, A., Gao, Q., Zhang, T., Ahmed, M.A., Sutamihardja, R.T.M. and Gregory, R. 2008. Mitigation of global GHG emissions from waste: conclusions and strategies from the Intergovernmental Panel on Climate Change (IPCC) fourth assessment report. Working group III (Mitigation). ***Waste Management and Research,*** Vol. 26, No.1, pp. 11-32.

Breschi, S. and Malerba, F. 2001. The geography of innovation and economic clustering: Some introductory notes. ***Industrial and Corporate Change,*** Vol. 10, No. 4, pp. 817-833.

Bresnahan, T., Gambardella, A. and Saxenian, A. 2001. Old economy inputs for new economy outputs: Cluster formation in the new Silicon Valleys. ***Industrial and Corporate Change***, Vol. 10, No. 4, pp. 835-860.

Brockhaus, R. The Psychology of an Entrepreneur in: Kent, Secton and Vesper (eds.),

Encyclopedia of Entrepreneurship, **(**Englewood Cliffs: NJ Prentice Hall, 1982).

Bull, I. and Willard, G. Towards a theory of entrepreneurship in: Bull, Thomas and Willard (eds.), ***Entrepreneurship: Perspectives on Theory Building,*** (Oxford: Pergamon publishers, 1995).

Chawla, O.P. in: Chawla (ed.), ***Advances in Biogas Technology,*** (New Delhi: Publications and information division, Indian council of agricultural research, 1986).

Cofie, O.O., Drechsel, P., Agbottah, S. and Veenhuizen, van R. 2009. Resource recovery from urban waste: Options and challenges for community-based composting in sub-Saharan Africa. ***Desalination,*** Vol. 248, pp. 256-261.

Cointreau, S. Occupational and environmental health issues of solid waste management: special emphasis on middle- and lower-income countries in: Cointreau (ed.), ***Urban Papers,*** (Washington: The World Bank, 2006).

Coleman, J.S. 1988. Social capital in the creation of human capital. ***American Journal of Sociology,*** Supplement: Organizations and Institutions, pp. S95-S120.

Coleman, J.S. in: Coleman (ed.), ***Foundations of Social Theory,*** (Cambridge: Harvard University Press, 1990).

Commander, S., Davoodi H. and Lee, U.J. The causes and consequences of government for growth and wellbeing in: Commander, Davoodi and Lee (eds.), ***Background paper for World Development Report,*** (Washington DC: World Bank, 1997).

Couth, B. and Trois, C. 2010. Carbon emissions reduction strategies in Africa from improved waste management – A review. ***Waste Management,*** Vol. 30, pp. 2347-2353.

Cox, P.M., Betts, R.A., Jones, C.D., Spall, S.A., Totterdell, I.J. 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. ***Nature,*** Vol. 408, Issue 6809, pp. 184-187.

Dacin, T.M., Hitt, M.A. and Levitas, E. 1997. Selecting partners for successful international alliances: examination of U.S. and Korean firms. ***Journal of World Business***, Vol. 32, No. 1, pp. 3-16.

Dana, L.P. 1993. Environment for entrepreneurship: a model of public policy and economic development. ***The Journal of Entrepreneurship,*** Vol. 2, No. 1, pp. 73-86.

Dawson, J. and Jeans, A. in: Dawson and Jeans (eds.), ***Looking beyond credit: business development services and the promotion of innovation among small producers,*** (London: Intermediate Technology, 1997).

DFID. 1999. Research development and design of a simple solid waste incinerator: Review of demand and selection of partner country. ***Report published by Intermediate Technology Consultants Limited***, pp. 1-42.

Diamadopoulos, E., Koutsantonakis, Y. and Zaglara, V. 1995. Optimal design of municipal solid waste recycling systems. ***Resources, Conservation and Recycling,*** Vol. 14, No. 21, pp. 21-34.

Dollar, D., Hallward-Driemeier, M. and Mengistae, T. 2005. Investment climate and firm performance in developing economies. ***Economic Development and Cultural Change***, Vol. 54, No. 1, pp. 1–30.

Eckstein, A. 1957. Investment criteria for economic development and the theory of intertemporal welfare. ***Quarterly Journal of Economics,*** Vol. 71, No. 1, pp. 56-85.

Emission Inventory Improvement Program (EIPP) Chapter 7 Manure Management in: EIIP Greenhouse gas committee (eds.), ***Methods for estimating greenhouse gas emissions from manure management***, (Virginia: ICF Consulting, 1999).

Eisenhardt, K.M. and Graebner, M. E. 2007. Theory building from cases: opportunities and challenges. ***Academy of Management Journal***, Vol. 50, No. 1, pp. 25-32.

Ezzati, M., Lopez, A.D., Rodgers, A., Hoorn van der S., Murray, C.J.L. 2002. Selected major risk factors and global and regional burden of disease. ***Lancet,*** Vol. 360, Issue 9343, pp. 1347-1360.

FAO, ***Global Forest Resources Assessment 2005: Progress towards sustainable forest management,*** (Rome: Food and Agriculture Organization of the United Nations, 2005).

Fei, J.C.H. and Ranis, G. in: Fei and Ranis (eds.), ***Development of the labour surplus economy,*** (Irwin: Homewood IL, 1964).

Floress, K., Baumgart-Getz, A., Propoky L.S. and Janota, J. 2009. The quality of greenways planning in northwest Indiana: a focus on sustainability principles. ***Journal of Environmental Planning and Management***, Vol. 52, No. 1, pp. 61–78.

Friedrich, E. and Trois, C. 2011. Quantification of greenhouse gas emissions from waste management processes for municipalities- A comparative review focusing on Africa. ***Waste Management,*** Vol. 31, pp. 1585-1596.

Fritsch, M. 2008. How does new business formation affect regional development? Introduction to the special issue. ***Small Business Economics,*** Vol. 30, No. 1, pp. 1-14.

Fromhold,-Eisebith, M. and Eisebith, G. 2005. How to institutionalize innovative clusters? Comparing explicit top-down and implicit bottom-up approaches. ***Study Policy,*** Vol. 34, pp. 1250-1268.

Fullerton, D. G., Brucec, N. and Gordona, S.B. 2008. Indoor air pollution from biomass fuel smoke is a major health concern in the developing world. ***Transactions of the Society of Tropical Medicine and Hygiene***, Vol. 102, pp. 843-851.

Geddes, M. and Newman, I. 1999. Evolution and conflict in local economic development. ***Local Economy,*** Vol. 13, No. 5, pp. 12-25.

Gibson, A. 1997. Business development services – core principles and future challenges. ***Small Enterprise Development,*** Vol. 8, No. 3, pp. 1-11.

Gill, J. and Johnson, P. in: Gill and Johnson (eds.), ***Study methods for managers 3rd ed***., (London: Sage Publications, 2002).

Goedhuys, M. and Sleuwaegen, L. 2000. Entrepreneurship and growth of entrepreneurial firms in Cote D'Ivore. ***Journal of Development Studies,*** Vol. 36, pp. 122-145.

Goldman, I. A framework for monitoring and evaluation of pro-poor local economic development in: Goldman (ed.), ***The World Bank- Netherlands Partnership Program – Evaluating and Disseminating Experiences in Local Economic Development (LED),*** (Washington DC: World Bank Institute, 2005).

Government of Tanzania. 2000. ***Poverty Reduction Strategy Paper,*** pp. 1-53.

Government of Tanzania. 2003a. ***Integrated Labour Force Survey of 2000/1,*** pp. 1-168.

Government of Tanzania. 2003b. The national energy policy 2003. ***Ministry of Energy and Minerals***.

Government of Tanzania. 2003c. Cattle Population. ***Ministry of Livestock Development and Fisheries.***

Government of Tanzania. 2005. The rural energy act 2005. ***Ministry of Energy and Minerals,*** pp. 1-26.

Government of Tanzania. 2008a. Monduli district socio-economic profile. ***Monduli District Council,*** pp. 1-92.

Government of Tanzania. 2008b. Manyara district socio-economic profile. ***Manyara District Council,*** pp. 1-17.

Government of Tanzania. 2008c. State of the environment study 2008. ***Division of Environment – Vice President's Office***, ISBN 9987-8990.

Government of Tanzania. 2009. Poverty and human development report 2009. ***Ministry of***

Finance and Economic Affairs, pp. 1-220.

Government of Tanzania. 2010a. The economic survey 2009. ***Ministry of Finance and Foreign Affairs***, pp. 1-258.

Government of Tanzania. 2010b. National Strategy for Growth and Reduction of Poverty II. ***Ministry of Finance and Economic Affairs,*** pp. 1-184.

Government of Tanzania. 2010c The economic survey 2009. ***The Ministry of Finance and Economic Affairs, Tanzania,*** pp. 1-236.

Government of Tanzania. ***Tanzania Demographic and Health Survey 2010,*** (Dar es Salaam: NBS and ICF Macro, 2011).

GTZ. 2007. Feasibility Study for a National Domestic Biogas Programme in Tanzania. ***Biogas for Better Life Project,*** pp. 1-72.

Hartmann, C. in: Raines (ed.), ***Cluster Development and Policy,*** (Ashgate: Aldershot, 2002).

Haughton, G. and Counsell, D. in: Haughton and Counsell (eds.), ***Regions, Spatial Strategies and Sustainable Development,*** (London: Routledge, 2004).

Helmsing, A.H.J. 2001. Local Economic Development – New generations of actors, policies and instruments. A summary study prepared for the UNCDF symposium Decentralization Local Governance in Africa. ***Draft Papers for the 2001 Cape Town Symposium***, pp. 59-78.

Helmsing, A.H.J. 2003. Local economic development: new generations of actors, policies and instruments for Africa. ***Public Administration and Development,*** vol. 23, pp. 67-76.

Henry, R.K., Yongsheng, Z., Jun, D. 2006. Municipal solid waste management challenges in developing countries: Kenyan case study. ***Waste Management,*** Vol. 26, pp. 92-100.

Hiremath, R.B., Shikha, S. and Ravindranath, N.H. 2007. Decentralized energy planning; modelling and application-a review. ***Renewable and Sustainable Energy Reviews,*** Vol. 11, pp. 729-752.

Hoornweg, D. and Laura, T. in: Hoornweg and Laura (eds.), ***What a Waste: Solid Waste Management in Asia,*** (New York: The World Bank, 1999).

Hulme, 2007. Integrating quantitative and qualitative study for country case studies of development. ***Paper drafted for Global Development Network Meeting on 'Comparative Analysis: Methodological Workshop',*** pp. 1-45.

Humphrey, J. and Schmitz, H. 2008. Inter-firm relationships in global value chains: trends in chain governance and their policy implications. ***International Journal of Technological Learning, Innovation and Development,*** Vol. 1, No. 3, pp. 258-282.

Hyden, G. Changing ideological and theoretical perspectives on development in: Himmelstrand, Kinyanjui and Mburugu (eds.), ***African Perspectives on Development,*** (London: James Curry, 1994).

Jeon, E.J., Bae, S.J., Lee, D.H., Seo, D.C., Chun, S.K., Lee, N.H. and Kim, J.Y. 2007. Methane generation potential and biodegradability of MSW components. ***Eleventh International Waste Management and Landfill Symposium, Sardinia***, pp. 1-8.

Jin, S. and Deininger, K. 2008. Key constraints for rural non-farm activity in Tanzania: Combining investment climate and household surveys. ***Journal of African Economies,*** Vol. 18, No. 2, pp. 319- 361.

Ji-Qin, N. and Nyns, E.J. 1995. Diffusion of rural biogas technology: Survey of experience. ***Science, Technology and Development,*** Vol. 13, No. 2, pp. 266-277.

Jonušauskait, G.2010. Perceived benefits & challenges of biogas adoption among households in Kenya. ***IVM Institute for Environmental*** **Studies**, pp. 1-59.

Jung, H.S. and Thorbecke, E. 2003. The impact of public education expenditure on human capital, growth, and poverty in Tanzania and Zambia: a general equilibrium approach. ***Journal of Policy Modelling,*** Vol. 25, pp. 701-725.

Kammen, D. and Kirubi, C. 2008. Poverty, energy, and resource use in developing countries: Focus on Africa. ***Annals of the New York Academy of Sciences***, 1136, pp. 348-357.

Kanbur, R. and Shaffer, P. 2006. Epistemology, normative theory and poverty analysis: implications for Q-Squared in practice. ***Working Paper 2006-02, Cornell: Department of Applied Economics and Management, University of Cornell,*** pp. 1-42.

Karekezi, S. 2002. Renewables in Africa, meeting the energy needs of the poor. ***Energy Policy***, Vol. 30, pp. 1059-1069.

Kaseva, M.E. and Gupta, S.K. 1996. Recycling-an environmentally friendly and income generating activity towards sustainable solid waste management. Case study-Dar es Salaam City, Tanzania. ***Resources, Conservation and Recycling,*** Vol. 17, pp. 299-309.

Kaseva, M.E., Mbuligwe, S.E. and Kassenga, G. 2002. Recycling inorganic domestic solid wastes: results from a pilot study in Dar es Salaam City, Tanzania. ***Resources, Conservation and Recycling,*** Vol. 35, pp. 243-257.

Kassenga, G.R. 1997. Promotion of renewable energy technologies in Tanzania. ***Resources, Conservation and Recycling,*** Vol. 19, pp. 257-263.

Kassim, S.M. and Ali, M. 2006. Solid waste collection by the private sector: Households' perspective-findings from a study in Dar es Salaam city, Tanzania. ***Habitat International,*** Vol. 30, pp. 769-780.

Keating, M. 2005. Policy convergence and divergence in Scotland under devolution. ***Regional Studies,*** Vol. 39, pp. 453-464.

Kennedy, C.A., Ramaswami, A., Carney, S. and Dhakal, S. Chapter two: Greenhouse gas emission baselines for global cities and metropolitan regions in: Hoornweg, Freire, Lee, Bhada-Tata and Yuen (eds.), ***Cities and Climate Change – Responding to an Urgent Agenda,*** (Washington: The World Bank, 2011).

Khalil, M.A.K. in: Khalil (ed.), ***Atmospheric Methane: It's Role in the Global Environment,*** (New York: Springer, 2000).

Kinda, T. and Loening, J.L. 2010. Small enterprise growth and the rural investment climate: evidence from Tanzania. ***African Development Review,*** Vol. 22, No. 1, pp. 173-201.

King, K. and McGrath, S. 1998. Rethinking small enterprise development: between poverty and growth. ***Centre for African Studies University of Edinburgh,*** paper presented at the conference: 'Enterprise in Africa: Between poverty and growth'.

Kiplagat, J.K., Wang, R.Z. and Li, T.X. 2011. Renewable energy in Kenya: Resource potential and status of exploitation. ***Renewable and Sustainable Energy Reviews,*** Vol. 15, pp. 2960-2973.

Kristiansen, S. 2001. Promoting African pioneers in business: what makes a context ______conducive to small-scale entrepreneurship? ***The Journal of Entrepreneurship,*** Vol. 10, No. 1, pp. 43-69.

Lashof, D.A. and Ahuja, D.R. 1990. Relative contributions of greenhouse gas emissions to global warming. ***Nature,*** Vol. 344, Issue 6266, pp. 529-531.

Lindert, P. van. Urban governance for development in: Hebinck, Slootweg and Smith (eds.), ***Tales of Development. People, Power and Space,*** (Assen: Van Gorcum, 2008).

Lucas, R.E. 1988. On the mechanics of economic development. ***Journal of Monetary Economics,*** Vol. 22, No. 1, pp. 1-42.

Malecki, E.J. in: Malecki (ed.), ***Technology and Economic Development: The Dynamics of***

Local, Regional and National Competitiveness (2nd Edition), (Essex: Longman, 1997).

Manga, V.E., Forton, O.T. and Read, A.D. 2008. Waste management in Cameroon: A new policy perspective? ***Resources, Conservation and Recycling,*** Vol. 52, pp. 592-600.

Marree, F. and Nijboer, M. 2007. Biogas: viable or not? An explorative study to the feasibility of introducing biogas and the impact on HH's livelihoods in the Northern regions of Tanzania. ***SNV – Netherlands Development Organization,*** pp. 1-266.

Martinot, E., Chaurey, A., Lew, D., Moreira, J.R. and Wamukonya, N. 2002. Renewable energy markets in developing countries. ***Annual Review of Energy and the Environment,*** Vol. 27, pp. 309-348.

Mata-Avarez, J. in: Mata-Avarez (ed.), ***Biomethanization of the organic fraction of municipal solid wastes,*** (London: IWA Publishing, 2003).

Mbuligwe, S.E. and Kassenga, G. 2004. Feasibility and strategies for anaerobic digestion of solid waste for energy production in Dar es Salaam city, Tanzania. ***Resources, Conservation and Recycling***, Vol. 42, pp. 183-203.

McCormick, D. Small enterprise development: A network approach in: McCormick and Pedersen (eds.), ***Small Enterprises: Flexibility and Networking in an African Context,*** (Nairobi: Longhorn, 1996).

McEwan, C. 2003. 'Bringing government to the people': women, local governance and community participation in South Africa. ***Geoforum,*** Vol. 34, pp. 469-481.

McGrath, S. and King, K. 1996. Learning to compete: African education, training and small enterprise development in the era of globalization. ***Centre of African Studies, University of Edinburgh.***

McGregor, D. Climate change and development in: Desai and Potter (eds.), ***The Companion to Development Studies (2nd Edition),*** (London: Hodder Education, 2008).

Mead, D.C. 1998. MSEs tackle poverty and growth (but in differing proportions). ***Centre for African Studies, University of Edinburgh,*** paper presented at the conference 'Enterprise in Africa: between poverty and growth'.

Meek, W.R., Pacheco, D.F. and York, J.G. 2010. The impact of social norms on entrepreneurial action: Evidence from the environmental entrepreneurship context. ***Journal of Business Venturing,*** Vol. 25, No. 5, pp. 493-509.

Melese, A.T. and Helmsing, A.H.J. 2010. Endogenisation or enclave formation? The development of the Ethiopian cut flower industry. ***Journal of Modern African Studies,*** Vol. 48, No. 1, pp. 35-66.

Misra, V. and Pandey, S.D. 2005. Hazardous waste, impact on health and environment for development of better waste management strategies in India. ***Environment International,*** Vol. 31, pp. 417-431.

Mkiramweni, L.L.N and Mshoro, I.B .2009/2010. Estimating the Potential for Biogas Production and Application in Morogoro Region, Tanzania. ***Energy and Environment***, 20/21, (8/1), pp. 1357-1368.

Mshandete, A.M. and Parawira, W. 2009. Biogas technology study in selected sub-Saharan African countries – A Review. ***African Journal of Biotechnology,*** Vol. 8, No. 2, pp. 116-125.

Monni, S., Pipatti, R., Lehtilä, A., Savolainen, I. and Syri, S. 2006. Global climate change mitigation scenarios for solid waste management. ***VTT Publications 603,*** pp. 1-55.

Müller, C. Anaerobic digestion of biodegradable solid waste in low-and middle-income countries: Overview over existing technologies and relevant case studies in: Müller (ed.), ***Swiss Federal Institute for Aquatic Science and Technology (EAWAG) Publication***, (Dubendorf: EAWAG, 2007).

Murphy, J.T. 2001. Making the energy transition in rural East Africa: Is leapfrogging an alternative? ***Technological Forecasting and Social Change***, Vol. 68, pp. 173-193.

Muzzini, E. and Lindeboom, W. ***The Urban Transition in Tanzania: Building the Empirical Base for Policy Dialogue,*** (Washington: The World Bank, 2008).

Mwakaje, A.G. 2008. Dairy farming and biogas use in Rungwe district, South-west Tanzania: A study of opportunities and constraints. ***Renewable and Sustainable Energy Reviews,*** 12, pp. 2240–2252.

Nauwelaers, C. Path-dependency and the role of institutions in cluster policy generation in: Mariussen (ed.), ***Cluster Policies–Cluster Development?*** (Stockholm: Nordregio, 2001).

Navickas, V. and Malakauskaite, A. 2010. The impact of clusterization on the development of small and medium-sized enterprise (SME) sector. ***Journal of Business Economics and Management,*** Vol. 10, No. 3, pp. 255-259.

NBS (National Bureau of Statistics). 2009. ***Household Budget Survey 2007 Tanzania Mainland*** (Final Document 6 May 2009).

Newlands, D. 2003. Competition and cooperation in industrial clusters: the implication for public policy. ***European Planning Studies,*** Vol. 11, pp. 521-532.

Nkya, E.J. 2003. Institutional barriers to small-scale business development: a need for flexibility in Tanzanian tax and regulatory systems. ***The Journal of Entrepreneurship,*** Vol. 12, No. 1, pp. 43-73.

Oliveira, J.A.P. in: Oliveira (ed.), ***Upgrading clusters and small enterprises in developing countries***, (Ashgate: Ashgate Economic Geography, 2008).

O' Riordan, J., Swai, F. and Rugumyamheto, A. 1997. Educational background, training and their influence on female-operated informal sector enterprises, ***REPOA,*** pp. 1-46.

Parawira, W. 2009. Biogas technology in sub-Saharan Africa. status, prospects and Constraints. ***Environmental Science and Bio-Technology***, Vol. 8, pp. 187–200.

Parmesan, C. and Yohe, G. 2003. A globally coherent fingerprint of climate change impacts across natural systems. ***Nature,*** Vol. 421, Issue 6918, pp. 37-42.

Pike, A., Rodríguez-Pose, A. and Tomaney, J. Local and Regional Development in: Pike, Rodríguez-Pose and Tomaney (eds.), ***Local and Regional Development***, (London and New York: Routledge, 2006).

Quadir, S.A., Mathur, S.S. and Kandpal, T.C. 1995. Barriers to dissemination of renewable energy technologies for cooking. ***Energy Conversion and Management,*** Vol. 36, No. 12, pp. 1129-1132.

Reddy, B.S. Energy and development in: Desai and Potter (eds.), ***The Companion to Development Studies,*** (London: Hodder Education, 2008).

Reuber, R. and Fisher, E. in: Reuber and Fisher (eds.), ***Industrial clusters and SME promotion in developing countries,*** (London: Commonwealth Secretariat, 2001).

Rigg, J. The millennium development goals in: Desai and Potter (eds.), ***The Companion to Development Studies,*** (London: Hodder Education, 2008).

Rogerson, C.M. 2001. In search of the African miracle: Debates on successful small enterprise development in Africa. ***Habitat International,*** Vol. 25, Issue 1, pp. 142-155.

Romer, P. 1990. Endogenous technological change. ***Journal of Political Economy,*** Vol. 98, No. 5, pp. 71-102.

Ruttan, V.W. in: Ruttan (ed.), ***United States development assistance policy: the domestic politics of foreign economic aid,*** (Baltimore: John Hopkins University Press, 1996).

Saini, J.S. and Bhatia, B.S. 1996. Impact of entrepreneurship development programmes. ***The Journal of Entrepreneurship***, Vol. 5, No. 1, pp.

Sasse, L., Kellner, C., Kimaro, A. Improved biogas unit for developing countries in: Sasse, Kellner and Kimaro (eds.), ***Deutsche Geselschaft für Technische Zusammenarbeit (GTZ),*** (Wiesbaden: GTZ, 1991).

Satterthwaite, D. Urbanization and environment in low- and middle- income nations in: Desai and Potter (eds.), ***The Companion to Development Studies,*** (London: Hodder Education, 2008).

Schoot Uiterkamp, B.J., Azadi, H. and Ho, P. 2011. Sustainable recycling model: a comparative analysis between India and Tanzania. ***Resources, Conservation and Recycling***, Vol. 55, No. 3, pp. 344-355.

Schoot Uiterkamp, B.J. and Pennink, B.J. 2011. Assessment of local capacity development interventions in Indonesia: Model development and first empirical results. ***The South East Asian Journal of Management*** (Forthcoming: October 2011).

Sépulveda, A., Schluep, M., Renaud, F.G., Streichner, M., Kuehr, R., Hagelücken, C. and Gerecke, A.C. 2009. A review of the environmental fate and effects of hazardous substances released from electrical and electronic equipments during recycling: examples from China and India. ***Environmental Impact Assessment Review,*** Vol. 30, No. 1, pp. 28-41.

Shafi, M. Key note address in: Mohammad, Siddiqui and Ibrahim (eds.), ***Environment, Agriculture and Poverty in Developing Countries,*** (New Delhi: Concept Publishing Company, 2006).

SNV. 2009. Programme implementation document. ***Tanzania Domestic Biogas Programme,*** pp. 1-95.

Storper, M. in: Storper (ed.), ***The regional world: Territorial development in a global Economy,*** (London: Guilford, 1997).

Sunderam-Stukel, R., Deininger, K. and Jin, S. 2007. Fostering growth of the rural non-farm sector in Africa: the case of Tanzania. ***Background paper for the Tanzania pilot rural investment climate assessment,*** pp. 1-32.

Swinborn, G., Goga, S. and Murphy, F. 2006. Local Economic Development: A primer developing and implementing local economic development strategies and action plans. ***World Bank working paper***, pp. 1-91.

Szirmai, A. in: Szirmai (ed.), ***The dynamics of socio-economic development***, (Cambridge: Cambridge University Press, 2005).

Thorbecke, E. 2006. The evolution of the development doctrine, 1950-2005. ***United Nations University - UNU-WIDER World Institute for Development Economics Study,*** Study paper No. 2006/155, pp. 1-34.

Troschinetz, A.M. and Mihelcic, J.R. 2009. Sustainable recycling of municipal solid waste in developing countries. ***Waste Management,*** Vol. 29, pp. 915-923.

Tvaronaviciene, M. and Korsakiene, R. 2007. The role of government in implementing innovation. ***Business, Theory and Practice,*** Vol. 8, No. 1, pp. 9-13.

UN DESA. ***World Population Prospects: The 2006 Revision,*** (New York: United Nations Department of Economic and Social Affairs, 2007).

UNDP. ***Human Development Report 2010: The Real Wealth of Nations, Pathways to Human Development,*** (New York: United Nations Development Programme, 2010).

United Nations Framework Convention on Climate Change (UNFCCC). 2005. ***Sixth Compilation and Synthesis of Initial National Communications from Parties not Included in Annex 1 to the Convention: Inventories of Anthropogenic Emissions by Sources and Removals by Sinks of Greenhouse Gases,*** pp. 1-20.

UN-Habitat. ***Promoting Local Economic Development through strategic planning: The Local Economic Development Series (Volume 1),*** (Nairobi: United Nations Human Settlements Programme, 2005).

UN Habitat. ***The State of African Cities 2010: Governance, Inequality and Urban Land Markets***, (Nairobi: United Nations Human Settlements Programme, 2010).

UN Habitat. ***Cities and Climate Change: Policy Directions – Global Report on Human Settlements,*** (London – Washington D.C.: United Nations Human Settlements Programme, 2011).

UN Tanzania. ***United Nations Development Assistance Plan (2011-2015),*** (Dar es Salaam: United Nations Tanzania, 2010).

U.S. EPA. ***Global Mitigation of Non-CO2 Greenhouse Gases,*** (Washington: United States Environmental Protection Agency: 2006).

Voegeli, Y., Lohri, C., Kassenga, G., Baier, U. and Zurbrügg, C. 2009. Technical and biological performance of the Arti compact biogas plant for kitchen waste- Case study from Tanzania. ***Paper presented at the Twelfth International Waste Management and Landfill Symposium,*** pp. 1-9.

Wang, L., Prieto, L. and Hinrichs, K.T. 2010. Direct and indirect effects of individual and environmental factors on motivation for self-employment. ***Journal of Developmental Entrepreneurship,*** Vol. 15, No. 4, pp. 481-502.

Wedgwood, R. 2007. Education and poverty reduction in Tanzania. ***International Journal of Educational Development,*** Vol. 27, pp. 383-396.

Weiland, P. 2010. Biogas production: current state and perspectives. ***Applied Microbiological Biotechnology,*** Vol. 85, pp. 849-860.

Westlund, H. and Bolton, R. 2003. Local social capital and entrepreneurship. ***Small Business Economics,*** Vol. 21, pp. 77-113.

White, H. 2002. Combining quantitative and qualitative approaches in poverty analysis. ***World Development***, Vol. 30, No. 3, pp. 511-522.

WHO and UNDP. The energy access situation in developing countries: A review focusing on the least developed countries and Sub-Saharan Africa in: ***United Nations Development Programme Publication,*** (New York: UNDP, 2009).

Woller, G. Chapter 17: A review of impact assessment methodologies for Microenterprise development programs in: Nolan and Wong (eds.), ***Evaluating Local Economic and Employment Development- How to assess what works among programs and policies,*** (Paris: OECD, 2004).

Wolfe, D.A. and Gertler, M. 2004. Clusters from the inside and out: local dynamics and global linkages. ***Urban Studies,*** Vol. 41, pp. 1071-1093.

Woolcock, M. Social capital and economic development: Toward a theoretical synthesis and policy framework in: Woolcock (ed.), ***Theory and Society 27,*** (Amsterdam: Kluwer Academic Publishers, 1998).

World Bank 2004a. Programme document for a proposed financing to the United Republic of Tanzania for a Secondary Education Development Programme, ***World Bank Report No. 27613***.

World Bank. 2004b. A better investment climate for everyone. ***World Development Study, 2005,*** pp. 1-272.

World Bank. 2009. Environmental Crisis or Sustainable Development Opportunity? Transforming the charcoal sector in Tanzania, A Policy Note, ***The World Bank,*** pp. 1-72.

Xinyu, L. 2010. Comparative analysis of urban and rural biogas development in China.

Journal of Urban Technology, Vol. 17, No. 3, pp. 25-37.

Yin, R.K. in: Yin (eds.), ***Case study study: design and methods, 2nd ed.,*** (Newbury Park, Sage, 1994).

Internet Sources

EU Climate Data. 2011. ***Climate Tanzania,*** <http://www.climatedata.eu/country.php?cc=tz&lang=en>, (Retrieved: 01-08-2011).

CIA The World Factbook. 2011. ***Africa – Tanzania,*** <https://www.cia.gov/library/publications/the-world-factbook/geos/tz.html>, (Retrieved: 28-07-2011).

FAO. 2011. ***The United Republic of Tanzania – Maps,*** < http://www.fao.org/countryprofiles/maps.asp?iso3=TZA&lang=en>, (Retrieved: 04-08-2011).

Freedom House. 2010. ***Freedom in the World 2010, Erosion of Freedom intensifies, Tanzania***, <http://www.freedomhouse.org/template.cfm?page=22&year=2010&country=7931>, (Retrieved: 18-08-2011).

Government of Tanzania.2011b. ***Livestock,*** <http://www.tanzania.go.tz/livestock.html>, (Retrieved: 18-08-2011).

International Energy Agency (IEA) Statistics Division. 2007. ***Energy Balances of OECD Countries (2008 edition)*** **and** ***Energy Balances of Non-OECD Countries (2007 edition),*** <http://data.iea.org/ieastore/default.asp>, (Retrieved: 10-05-2011).

IFAD. 2010a. ***Rural poverty in Tanzania***, <http://www.ruralpovertyportal.org/web/guest/country/home/tags/tanzania>, (Retrieved: 04-12-2010).

IFAD.2010b. ***Geography, agriculture and the economy,*** <http://www.ruralpovertyportal.org/web/guest/country/geography/tags/tanzania>, (Retrieved: 04-12-2010).

Le Voyageur. 2011. ***Tanzania,*** <http://www.levoyageur.net/weather-TANZANIA.html>, (Retrieved: 01-08-2011).

National Bureau of Statistics. 2010. ***Tanzania Mainland in key statistics***, <http://www.nbs.go.tz/index.php?option=com_content&view=article&id=105&Itemid=109>, (Retrieved: 20-01-2011).

Mahat, I.2003. ***Gender dimensions in household energy***, <http://www.hedon.info/docs/BP49-11-Mahat.pdf>, (Retrieved: 13-05-2011).

Mwanza City Council. 2004/2005. ***Mwanza City Profile,*** < http://www.mwanza.de/index.php?option=com_content&view=article&id=52:mwanza-city-profile-english&catid=17:die-stadt-mwanza&Itemid=33&lang=en>, (Retrieved: 12-08-2011).

Reuters. 2011. ***Utility price hikes push demand for wood in Tanzania***, <http://www.trust.org/alertnet/news/utility-price-hikes-push-demand-for- wood-in-tanzania>, (Retrieved: 10-05-2011).

Sölvell, Ö, Lindqvist, G. and Ketels, C. 2003. ***The cluster initiative greenbook***, < http://www.ivorytower.se/eng/projgrnbk.htm>, (Retrieved: 10-05-2011).

Tanzania Domestic Biogas Programme (TDBP). 2011. ***Subsidy Component and Credit,*** <http://www.biogas tanzania.org/index.php/programmes/subsidy_component_and_credit/>, (Retrieved: 10-08- 2011).

The Citizen. 2011. ***Camartec to Produce Anaerobic Digesters used to Generate Clean Gas,*** < http://www.thecitizen.co.tz/sunday-citizen/40-sunday-citizen-news/13089-energy-camartec-to-produce-anaerobic-digesters-used-to-generate-clean-gas.html>, (Retrieved: 03-08-2011).

The World Bank 2011. ***What is Local Economic Development (LED)?,*** < http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/EXTLED/0,,contentMDK:20185186~menuPK:399161~pagePK:148956~piPK:216618~theSitePK:341139,00.html>, (Retrieved: 04-02-2011).

UNDP. 2011. ***Energy for Sustainable Development: Overview,*** < http://www.undp.org/energy/>, (Retrieved: 01-08-2011).

UNEP. 2011. ***Tanzania,*** **<**http://www.unep.org/ik/Pages.asp?id=Tanzania>, (Retrieved: 03-08-2011).

Appendix 1 Government Activities And View On Tanzanian Re-Sector

Stakeholder	Activities	Identified Barriers
Ministry of Energy and Minerals (MEM)	-Work on RE-policy (expected 2012) -Create awareness for ARETs through installation institutional ARETs -Tax exemptions on solar pv -Lobbying Members of Parliament (MPs) for RE -Training local technicians via VETA -Training local dealers to create distribution point in each district -Funds provided to REA to stimulate RE-entrepreneurship	-Lack of awareness for ARETs -Low affordability products since a lot of materials are imported -Low technical know-how -Distribution ARETs on district level
Rural Energy Agency (REA)	-Implement MEM policy to stimulate RET development and dissemination -Signpost to create awareness for RE needs for both private-, public- and non-governmental sector -Supports developers of ARETs to implement rural energy projects after conducting feasibility studies (matching-grand). 80 per cent investment costs covered by REA, 20 per cent by development partner	-Inferior methods are used by citizens to generate energy out of biomass -Lack of clear district level government strategies on RE -Low participation private sector (potential of public- private partnerships not clear to private sector; high upfront investment costs) -Insufficient quality ARETs (design, high maintenance costs, malfunctioning) -Lack of household awareness benefits ARETs, they should see ARETs first before using them
Division of Environment (DoE)	-Indirectly educate citizens via awareness trainings for LGAs per zone	-Citizens have lack of knowledge about the impact of their energy consumption behaviour for forests -Due to decentralization and autonomy for LGAs, DoE cannot force LGAs to implement national strategies -Too little resources to adequate train LGAs
Business Registrations and Licensing Agency (BRELA)	-Registers business names and companies (both not obligatory) -Sensitization campaign to make rural people aware of benefits registration business names	-Rural people are often not aware of benefits of registration business names

Tax and Revenue Authority (TRA)	-Tax collection via audits by TRA	

SOURCE: FIELD RESEARCH (2011)

Appendix 2 Liaison Activities And View On Tanzanian Re-Sector

Stakeholder	**Activities**	**Identified Barriers**
Tanzania Renewable Energy Association (TAREA)	Membership association, which: -provides consultancy services to MEM -Promotes sustainable RE-technologies via political lobbying for RE-policy development and favourable tax tariffs to stimulate dissemination ARETs -Raise awareness for RE via promotional activities	-Lack of awareness for need ARETs -Entrepreneurs have lack of business knowledge -Lack of technical know-how by technicians about installation of ARETs -High costs of solar and biogas -Lack of informed policy from government institutes. Current energy policy is from 2003 and only marginally addresses RE -REA does not function well since right RET knowledge is not in place
VETA	Parastatal training institute, which: -Provides training to young people in 21 occupations in every region of the country -2 year entrepreneurship course exists -Short entrepreneurship course is being developed, core will be to stimulate entrepreneurial attitude (subsidies can be provided by national government if a national interest is served)	-Tanzanians don't think they need training to start a business and don't want to pay for an entrepreneurship training or cannot pay for the training -People do not have confidence in potential of doing business -Long socialist history caused people to have low business-skills, is slow process to change -SMEs have difficulties getting access to finance from MFIs (slowly changing)
Small Industries Development Organization (SIDO)	Parastatal organization, located at 7 places in Tanzania which stimulates entrepreneurship via: -Training local RE-technicians in biomass (ICS), wind and solar to establish localized knowledge, skills and capacity -Afterwards, providing free location to 60 entrepreneurs in the Business Development Gateway (BDG) and offers loans to entrepreneurs	-Entrepreneurs are not aware of the benefits SIDO training activities offer

	-Member of Tanzania Renewable Efficient Energy Project for Rural Application (TRESPA)	
Stichting Nederlandse Vrijwilligers (SNV)	Dutch development organization, provides advisory services to: -Tanzania Domestic Biogas Programme (TDBP) -TAREA	-Domestic energy provision is a non-issue at national government level
Triodos Facet	Providing consultancy services to facilitate business development in RE-sector, among others for: -TATEDO	-Tanzanians are peaceful, but also passive, which is not an incentive for change and entrepreneurship -Decentralization of government authorities is good. However, since regions are autonomous, LGAs partially have to generate their own income, which results in a lot of bureaucratic nonsense taxes -National policies are being developed to facilitate business development, but on the ground nothing changes and corruption increases - Own initiative among population died as a result of Ujamaa, last year's improvements are being made but slowly -Entrepreneurship is not valued in the social setting, an office, or government job is valued higher in society
Tatedo	-NGO providing ARETs, such as biomass (ICS) and solar by setting up user- and producer groups of ARETs -Link entrepreneurs with SACCOS	-Financial barriers for both users and producers of ARETs -Lack of skills and knowledge of managing ARETs -Entrepreneurs often stop since current (ICS) market is saturated. Do not seek new markets
OIKOS	-In 2008, a three-year project started in Ol Doinyo and Ngare Nanyuki wards in Meru district, financed by the European Union (EU). Focus areas are water, food	-Lack of rural energy office, policy and energy awareness at LGAs

	security and energy. Women groups are supported in running RE-shops. The RE-shops sell ARETs like solar, ICS and biogas. The RE-shops work closely together with local producers by promoting their ARETs and doing their administration	
Round Table Africa (RTA)		-There is a lack of coordination of national government policies on ARETs -Commercial business development service providers are not affordable for entrepreneurs -Entrepreneurs are used to free services, they do not see the need for and value of business development services where they have to pay for -Government policies how to start businesses in Tanzania are not transparent
Tanzania Domestic Biogas Programme	The Tanzanian Domestic Biogas Programme (TDBP) aims at developing commercially viable private sector development in the RET biogas. Within a time-frame of five years (2009-2013) efforts are spend to create a domestic biogas sector	
USAWA Savings and Credit Cooperative Society (SACCOS)	Umbrella organization for 27 SACCOS in Northern Tanzania – predominantly in Kilimanjaro region. –Provides technical and financial support and advice to member SACCOS -Provides loan for ARETs, the eco-loan	-LGAs lack knowledge of networks and therefore do not see opportunities to innovate and to develop new loan products -LGAs try to exercise influence on cooperatives too much without right capacities to do so

SOURCE: FIELD RESEARCH (2011)

Appendix 3 Entrepreneurial Activities And Their View On The Tanzanian Re-Sector

Stakeholder	Activities	Identified Barriers
E+Co	Investment fund, which provides loans for 3-7 years to 20 carefully selected RE-enterprises in solar, biomass, LPG and small hydro and provides them enterprise development services	-Most businesses are informal, entrepreneurs have limited business skills and knowledge
Arusha Bio contractors Company (ABC) Ltd	Active in providing construction activities, also in RE (solar and wastewater recycling and previously in biogas).	-Biogas has low profit margins -Biogas customers often live in remote rural areas which makes quality supervision, promotion and after sales service expensive due to high transportation costs -Subsidies provided by donor programmes distort private sector development. Transportation and overhead need to be calculated to customer by enterprises, whereas subsidized programmes do not have to do this. For this reason it is hard for private companies to step in the market if a program is still running. -Masons lack entrepreneurial and business skills -Large share Tanzanians still thinks access to water and energy is a service which should be provided by the government -Entrepreneurship is not valued by society, working in-office or for the government has higher status -Biogas masons have wrong attitude: *"if assistance of donor stops, I will return to old business"*. Masons should learn how to plan for the future to overcome this attitude
ARTI	Dissemination of sustainable technologies for energy production to protect the environment, via: -solar, charcoal and biogas (urban model)	-National government has a lack of funding to change
Jackson	Informal ICS entrepreneur Arusha	-As informal entrepreneur it is hardly impossible to get access to capital
L's Solutions	Formal Solar and ICS entrepreneur based in Arusha.	-"*Current emphasis in training technicians to become entrepreneurs*

		is not right way to go. Training entrepreneurs and then link them with technicians" -"Entrepreneurial attitude forms largest barrier, not lack of finance; if you want to succeed as entrepreneur you will succeed" -Distribution of ARETs in rural areas is not successful if ARETs like solar are sold in cities. Transportation costs for customers from and to city equal product costs. Bring product to the people.

SOURCE: FIELD RESEARCH (2011)