

BIOGAS IN SENEGAL

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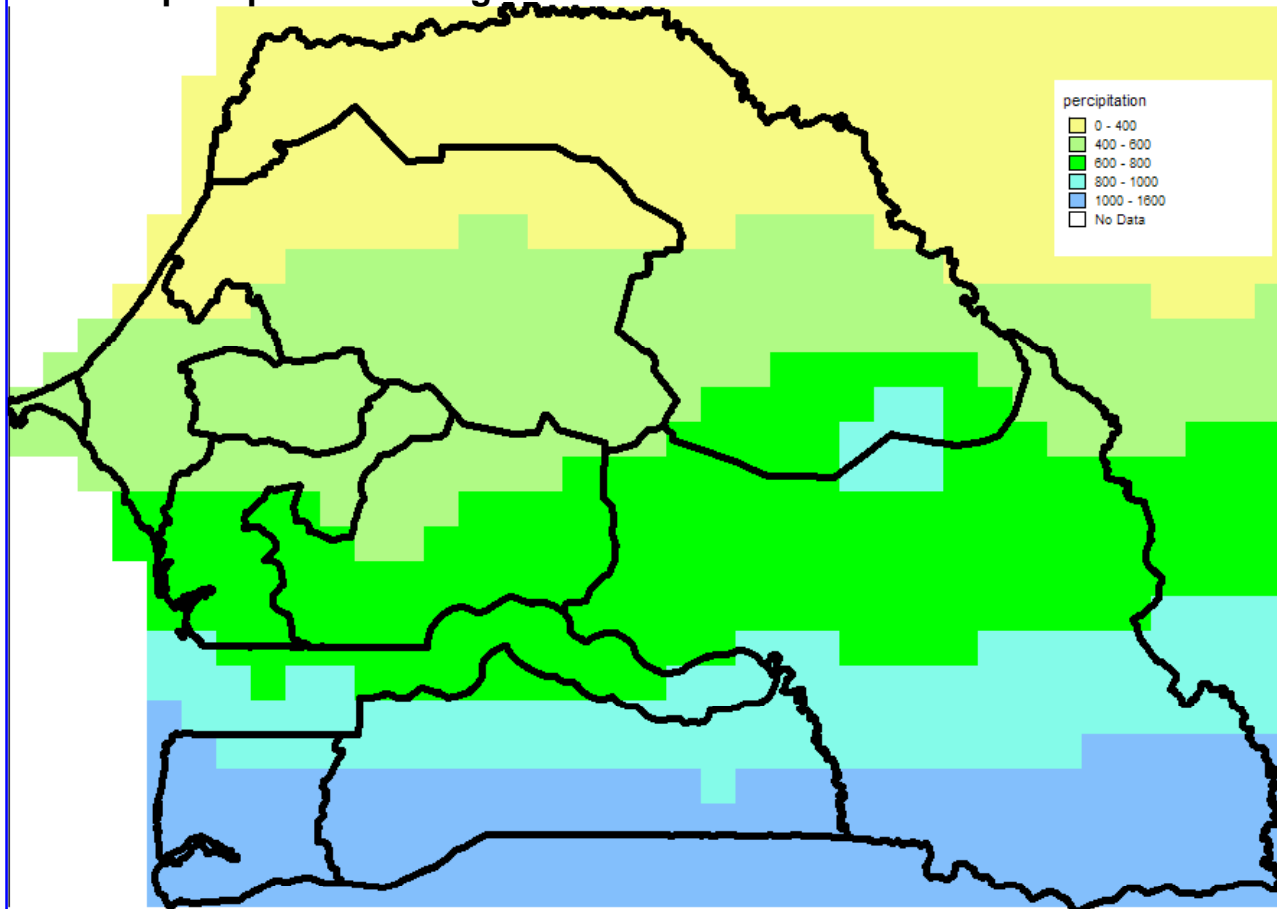
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**I GEOGRAPHY, CLIMATE AND
VEGETATION**

- Senegal is a coastal West African country (14° N, 14° W) with a total area of 1962 190 km².
- On land the nation borders with Mauritania to the north and Mali to the east along the Senegal River. In the south east and south, more or less following the Casamance River, Senegal borders Guinea and Guinea Bissau respectively, the Gambia, as a near enclave, penetrates into the country for more than 320 km from the Atlantic coast eastwards along the river with the same name.
- The local climate is tropical with well defined dry and humid seasons result from northeast winter winds and southwest summer winds.
- Current annual precipitation ranges from just under 300 mm in the northwest to over 1500 mm in the south of the country and falls between June and October.
- Temperatures range from minimum 15° C in January in the north west up to maximum 42 ° C in may along the eastern border with Mali. The mean temperature roughly increases from west to east from 25° to 30 °C.
- Vegetation of Senegal, from north to south, can be divided into sahelian, sudanian and Guinean Region.
- The sahelian region is between rainfall isoyeths of 150 and 300 mm in northern Senegal. The early seasonal rains, which usually begin in July, transform the landscapes into green, lush rangelands, drying out quickly after the last rains in late September. During the long dry season of 8 to 10 months, the herbaceous cover disappears as livestock and termites devour it, exposing bare soil to wind erosion. The together forming the dominant vegetation type of the Sahelian Region. The most common types are shrub savannas, shrubs and tree savannas, and bush lands. The woody cover rarely exceeds 6 to 8 meters in height.
- Sudanian Region lies to the south of the sahel, covering about two-thirds of central and southern Senegal. It is the domain of the savannah. The region predominates between the 300 mm and 700 mm isohyets. It is characterized by rainfall spread over 2 to 3 months of which July, August and September are nearly certain to have rain. A distinct dry season of 8 to 9 months is transformed into a wet, green, season by the first rains, triggering vigorous vigorous vegetation growth.
- The guinean Region is found in the extreme southwest corner of Senegal, although characteristics of this zone begin to manifest themselves in the southern sudanian Region. The annual rainfall varies between 700 mm to 1500 mm. Despite the high rainfall, this region has a distinctly dry season of 7 to 8 months, distinguishing it from the equatorial region of Africa.

Annual precipitation Senegal



II DEVELOPPEMENT AND ECONOMY

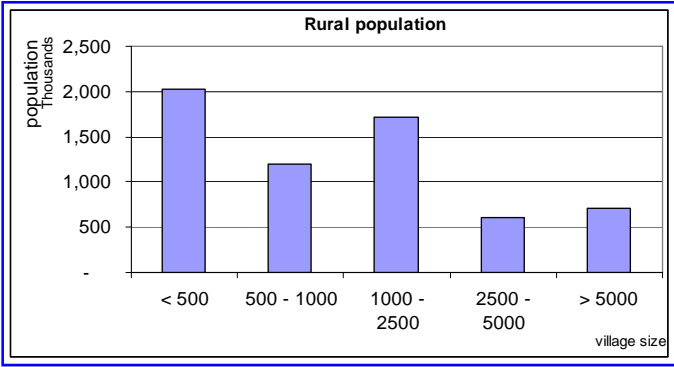
- A household survey in 1994 revealed that nearly 58% of Senegal's population was living below the poverty level. Despite the improvement due to economics reforms-GDP growth increased from 2.7% in 1994 to 5% in 2001-the share of the population living below the poverty level in the latter year remained as high as nearly 54%. Clearly, the progress of Senegal's economy hardly contributed to uplifting the conditions of the poor majority of the nation.
- For that reason, Senegal formulated its first **Poverty Reduction Strategy Paper** (PRSP) in 1997 aiming to increase income, improve access to basics services. The PRSP provides a framework for all interventions and actors in the socio-economic domain.
- The current PRSP document places energy as an important dimension in development. Domestically, access to clean, safe and sustainable energy is a precondition to improve the quality of life. Economically, energy is a main resource for production and it costs, directly affect the competitiveness of products.

III POPULATION

- Senegal's population is about 12 million inhabitants (census of 2006). Population growth rate is 2.7% per annum. At current rate, Senegal population will double every 25 years. There are 9 ethnical groups. The wolof (43%), Fula (25%), Serer (15%), Joola (5%), mandinka (4%) and others. Spatial distribution of the population is unbalanced. 65% of the population is concentrated in 14% of the territory. Population of Dakar metropolitan is 2.5 millions people. 56% of the total population is rural. But urbanization in Senegal is increasing every year at about 4%.



Main population characteristics				[2004]
Region	population [pers]	density pers/km ²	growth [avg/year]	rural [%]
Dakar	2,399,451	4363	3.0%	3%
Diourbel	1,144,009	262	3.9%	45%
Fatick	643,505	81	1.5%	91%
Kaolack	1,114,292	70	2.0%	79%
Kolda	893,867	43	2.6%	88%
Louga	714,732	24	2.4%	81%
Matam	461,836	18	3.9%	94%
Saint-Louis	738,724	39	3.7%	66%
Tambacounda	650,399	11	3.3%	84%
Thiès	1,358,658	206	2.3%	56%
Ziguinchor	444,830	61	0.7%	60%
Senegal	10,564,303	54	2.7%	56%



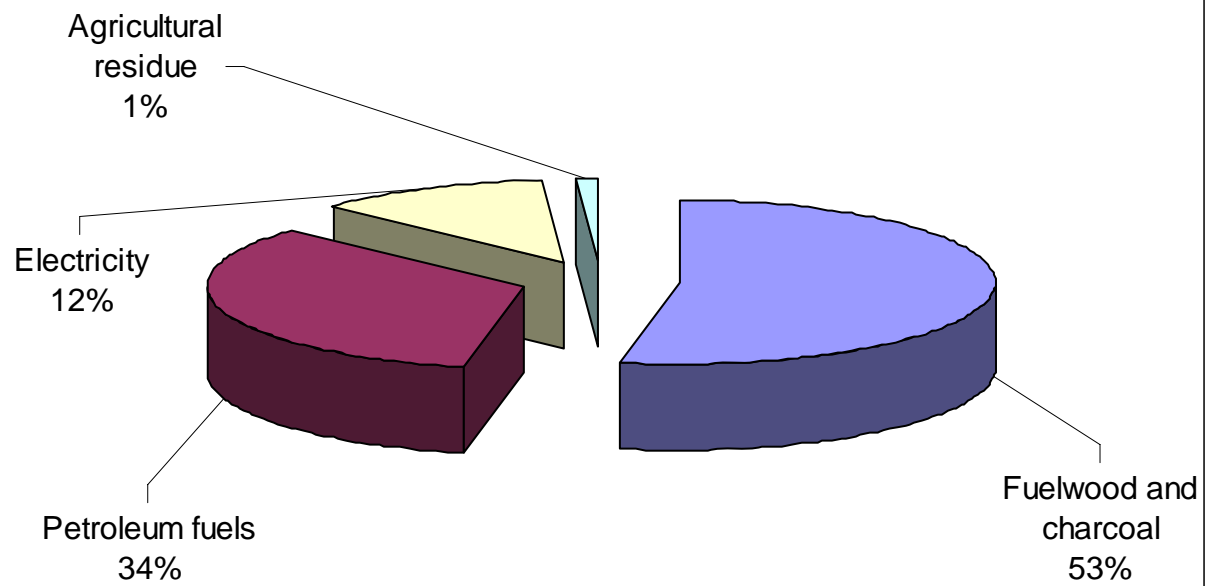
IV MAIN ECONOMIC INDICATORS

- During the period of 1960-1993, Senegal economic growth was at a rate of 2.7% per annum.
- From 1994, after the devaluation of the CFA currency, Senegal's economy shows a more rapid and robust development, maintaining annual economic growth figures from 5 to 6% per annum between 1999 and 2005.
- Economy is dominated by the tertiary sector : services (transportation, communication, business) supporting over 62% of the national production. Then comes the industrial sector which contributes to 21% GDP and agriculture contributes to the GDP to 17%. The agricultural sector employs 70 % of the rural population.. Farming is mainly done on small family farms (less than 3 ha). Agricultural families are typically large, with an average of 12 persons per family (7 of them involved in agricultural activities). Agriculture is mainly rain-fed. Main agricultural productions are .Ground peanuts, millet, corn, sorghum, rice cotton, tomatoes and green vegetables.
- Livestock in Senegal includes 3.2 million heads of cattle, 9.3 million sheeps and goats (about 50-50%), 330.000 pigs, 525,000 horses, 412,000 donkeys and 4,000 camels and 21.8 million poultry (mainly chicken).
- Pastoralists are located in the northern and the southeast regions of the country. They are the poorest groups of the country and livestock is their main source of wealth.

V ENERGY DEMAND AND SUPPLY

- Senegal's energy sector can be divided in the two relatively unrelated-sub-sectors of "traditional energy and modern energy".
- The main source of traditional energy is biomass. Biomass energy in Senegal includes mainly fuelwood and charcoal, but in the rural areas dung is used to some extent as cooking fuel as well.
- Modern energy includes petroleum products and electricity (mainly on thermal origin).
- Not unlike other west African countries, the relation between energy and environment is evident. In Senegal in particular, ecosystem degradation as a result of natural (rainfall deficit, drought) and anthropogenic factors (over-exploitation of forest, extensive agriculture, overgrazing, etc) is reaching levels that, for many regions of the country, threatens the very survival of its population.

Energy consumption by source (1992)



1 NATIONAL ENERGY CONSUMPTION

- The total energy consumption of Senegal is in the range of 20 to 30 million GWh per year. The lion share of the energy is consumed for residential use, mainly cooking and lighting.

ENERGY RESOURCES

- *wood fuels*
- It plays an important role in the provision of domestic and small industry energy. Despite this role, the forest sector officially only contributes to 1% of the country's GDP and 5% of the agricultural GDP; It is estimated that 75% of the wood production does not end up in the official statistics. Forest exploitation is estimated to have a turn over of 20 billion CFA franc per year, employing 20,000 persons. For 1995, 11.5 million ha was estimated to be covered with woody biomass which would equal to 60% of the country land area

- ***Fossil energy***

- The existence of fossil energy resources (oil and natural gas) was proven in the 50 and 60s of the previous century. Reserves of heavy oil, assessed on 100 million tones were discovered in the Casamance region. Natural gas and light oil were discovered in the Dakar region.

- ***Hydro-electric energy***
- The hydro-electric energy potential of the country, from its two large rivers the Senegal and the Gambia, is 1000MW. The hydro-electrical plant in the manantali dam upstream the
- Senegal has an installed capacity of 200 MW and provided Senegal 290 GWh of energy in 2004.

- ***Solar Energy***

- The solar energy potential of Senegal, with an average insolation of 6 kwh/m² and over 3000 hours of effective sun radiation per year, is significant. Solar energy can certainly play an important role in rural electrification, drainage, refrigeration, water heating and drying of produce and cost –wise competes in some areas with more traditional solutions.

- ***Wind energy***
- Wind energy would seem to have a favorable potential in Senegal as well. A strip of 50 km along the Atlantic coast in the west measures average wind speeds of 2 to 5 m/s, sufficient to power smaller pumping equipment.

- ***Domestic fuels***

- The urban cooking fuel differs significantly from rural customs. In an attempt to reduce deforestation (fuel wood,, charcoal production), the government started stimulating the use of butane gas in the 70 s. Particularly in the urban areas, promotion (and subsidies) had a good effect, resulting in butane gas being the main cooking fuel for 57% of the urban population in 2000
- In the rural area butane gas is only for 3% of the population, the main cooking fuel.
- Parallel to the introduction of butane gas, to back up reduction of wood-based fuels, the government of Senegal also pursued a policy to rationalize wood resource management.

VI BIOGAS

- When any organic matter such as animal dung, crop residue or kitchen waste is fermented in the absence of oxygen, biogas is generated. Biogas contains combustible: methane (60%) along with carbon dioxide and traces of other gases. This gas can serve as convenient fuel, for a variety of applications such as cooking, lighting and motive power. The bio-slurry that comes out of the plant after the gas is produced can be used-directly or as a composting agent-as organic manure to augment soil fertility. Thus biogas technology produces fuel without impairing the fertilizer value of the organic matter.
- Biogas production is a bio-chemical process occurring in three stages: hydrolysis, acidogenesis and methanogenesis, during which different bacteria act upon the organic matter resulting in the formation of methane and acids. The main factors influencing biogas production are the level of acidity of the feedstock and the temperature. It is well established that biogas plants work best with a near to neutral solution and a temperature of around 35°.

Anaerobic digestion process

Hydrolysis

Acidogenesis

Methanogenesis

Complex organic matter

Fermentative bacteria

Organic acids alcohols

CH_3COOH Acetate

$\text{H}_2 + \text{C}_2\text{HCOOH}$ Formate

Acetogenic bacteria

$\text{CH}_4 + \text{CO}_2$

$\text{CH}_4 + \text{CO}_2$

Methanogenic bacteria

Biogas

History of biogas in Senegal

- Although Senegal's history in biogas technology tracks back to the 50's of the previous century, it took until 1977, a revival of interest in biogas resulted in the construction of two Indian model (floating drum) biogas digester by CARITAS Senegal at NDIOUK Fissel, county of Thiadiaye .
- Main actors in the development of biogas in Senegal include:
 - -l'Ecole Supérieure Universitaire de Technology (ENSUT),
 - -Centre National de Recherche Agronomique de Bambey (CNRA),
 - -le Centre d'Etudes et de Recherches sur les Energies Renouvelables(CERER),
 - -le Centre Régional Africain de Technologie (CRAT)
 - -le Centre de Coopération International de Recherche Agronomique (CIRAD)
 - -l'Institut Sénégalais de Recherches Agricoles (ISRA)
 - -le Ministère de la Recherche Scientifique et Technique (MRST),
 - -la Société d'Aménagement et d'Etudes du delta (SAED)
 - - l'ENDA(Environnement et Développement du Tiers Monde)

- Initially ISRA attempted to build a floating drum technology with as main substrate a mix of agriculture waste and animal dung. The objective was two fold: production of a high quality organic fertilizer and generation of renewable energy. However, the investment costs of this type of installation in combination with high maintenance requirement prohibited popular dissemination.
- For that reason, ISRA –in cooperation with IRAT and financed by l'Agence Française pour la maîtrise de l'Energie (AFME) proposed the introduction of the transpaille biogas digester. This type of installation is constructed entirely out of sheet metal and typically connected with a dual fuel engine (20% diesel/80% biogas) for electricity generation. The first prototype was built in Bambey at the ISRA center . Other transpaille followed in the Dakar region in a diary farm in 1983.

- CRAT and CERER built two units in 1989; the first one in Dakar (10m³) and the later an other in sassal (30m³). In 1989 a large transpaille was installed in Thiès in order to manage the slaughter waste of the city.
- In 1989 two large biogas installations (2000 and 3000 m³) were put in Camberène, Dakar for waste water treatment. The generated biogas (1500 to 2000m³ daily) is used for electricity generation (200kw) and to heat water.

- En 1990, la SAED et AGRIFORCE ont repris la technologie du transpaille pour la développer sous l'appellation « SANIGAZ » dont l'équipement comprenait un fermenteur de 3,5 m³ (de construction locale en métal), un stockage de gaz de 2,5 m³ et un brûleur de 10 kW. 12 unités de SANIGAZ ont été mises en place principalement dans la région de Ross Béthio dans le delta du fleuve Sénégal: 6 unités dans le village de Kassack Nord, 3 unités dans celui de Mbane, 1 unité dans celui de Ndombo et 2 unités dans celui de Thiagar. Ces unités étaient alimentées par du fumier essentiellement composé de paille de riz. Leur production étaient de 3 à 10 m³ de biogaz par semaine. Le coût d'installation du digesteur est d'environ 1,5 million de FCFA
- Les femmes bénéficiaires de ces installations ont été particulièrement contentes dans la mesure où elles ont réussi à engager une partie de la famille dans la collecte des matières pour l'alimentation des digesteurs et le système semble fonctionner à leur convenance.
- Les conclusions définitives sur la viabilité économique du système sont que même si les investissements peuvent être justifiés à long terme, il est peu probable que les fermiers s'engagent dans de tels investissements privés en raison de leur niveau de revenus.

- De 1983 à 1990, l'ENDA a construit plusieurs digesteurs de type discontinu dans les régions de Thiès, Kolda et Ziguinchor.

- In total, some 42 biogas installations have been constructed in Senegal: 2 large industrial units, some 7 smaller fixed dome plants, 11 transpaille installations and 22 sanigaz (floating drum) units. Most of them are not currently in operation.

- 1994 Study on the utilization of BIOGAZ Technology for the Treatment of Industrial Wastes in Morocco, Senegal and Tunisia.
- Study was funded by UNIDO and conducted by Danish institute of Technology and Carl Bro Environment.
- 1995 Study on the feasibility of biogas Technology for pumping water from deep wells. Study was funded by Senegalese government.
- 1997 Study on the feasibility of utilizing biogas for food cooking in senegalese jails. The study was funded by Enda Tiers Monde

Millennium Development Goals

- Eradicate extreme hunger and poverty
- Achieve universal primary education
- Promote gender equality and empower women
- Reduce child mortality
- Improve maternal health
- Combat HIV/AIDS, malaria and other diseases
- Ensure environmental sustainability
- Develop a global partnership for development

Domestic biogas programmes contribute to reaching the UN-MDGs in the following ways:

- **MDG 1 Eradicate extreme poverty and hunger.**
- *Target 1: To halve extreme poverty*
- In general, households who install biogas are not amongst the poorest of the poor due to the fact that for a biogas plant to function a household must have a minimum number of animals that is often more than a very poor family has. However, the biogas dissemination process and the resulting reduced claim on common ecosystem services do affect the livelihood conditions of (very) poor non-biogas households as well. For example:
 - Construction and installation of biogas creates employment for landless rural people
 - Biogas saving on the use of traditional cooking fuels increases the availability of these fuels for (very) poor members of the community
 - Pollution control and waste management benefit all members of the community

- **MDG 3 Promote gender equality and empower women.**
- *Target 4: Eliminate gender disparity in education*
- It is predominantly women and girls who spend the most time and effort providing traditional energy services and using a domestic energy supply. Biogas directly benefits this group in the following ways:
- Biogas can provide light that helps women and girls to extend the amount of time in the day that they can study and gain access to education and information or engage in economic activities.
- Domestic biogas reduces the workload of women by reducing the need to collect firewood, tend fires and clean the soot from cooking utensils. This can save on average 2-3 hours per household per day
- The reduced smoke from replacing traditional fire wood stoves with biogas can improve the health of women (and children) who are most exposed to the dangers of wood smoke.
- The provision of biogas can provide an additional or more cost effective home based energy source that can enable women to participate in home based enterprises to generate additional income or at least generate income in a way that suits their life and obligations

- **MDG 4 Reduce child mortality.**
- *Target 5: Reduce by two-thirds (2/3) the under-five mortality rate*
- Half of the world's population cooks with traditional (mostly biomass based) energy fuels. Indoor air pollution from burning of these fuels kills over 1.6 million people each year, out of which indoor smoke claims nearly one million children's (<5) lives per year. Diseases that result from a lack of basic sanitation, and the consequential water contamination, cause an even greater death toll, particularly under small children (<5 mortality caused by diarrhoea is approximately 1.5 million persons per year). **Biogas and the Millennium Ecosystem Assessment**
- **As part of the implementation of the MDGs, the Millennium Ecosystem Assessment was released in March 2005. This assessment examined the relationship between ecosystems and achieving the MDGs. It not only found that not sustainable ecosystem management and development are imperative for reaching the MDGs, but moreover that ecological limits to worldwide growth will affect both developed and developing countries.**
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- **In addition to providing predictions and evidence the assessment provided a series of proposed responses and interventions. Biogas programmes have elements that are relevant to each of these responses and interventions.**
- Biogas stoves substitute conventional cook stoves and energy sources, virtually eliminating indoor smoke pollution and, hence, the related health risks that particularly affect children who are often heavily exposed to indoor smoke.
- Biogas significantly improves the sanitary condition of the farm yard and its immediate surrounding, lowering the exposure of household members to harmful infections especially children who spend extended periods in the farm yard.
- Proper application of bio-slurry will improve agricultural production (e.g. vegetable gardening), thus contributing to food security for the community.

- **MDG 6: Combat HIV/AIDS, malaria and other diseases.**
- *Target 8: Halt / reverse the incidence of malaria and other major diseases*
- Indoor air pollution and poor sanitary conditions annually cause millions of premature deaths.
- Biogas virtually eliminates health risks (e.g. respiratory diseases, eye ailments, burning accidents) associated with indoor air pollution.
- Biogas improves on-yard manure and night-soil management, thus improving sanitary conditions and protecting freshwater sources, lowering the exposure to harmful infections generally related with polluted water and poor sanitation.

- **MDG 7 Ensure environmental sustainability**
- Domestic biogas can help to achieve sustainable use of natural resources, as well as reducing (GHG) emissions, which protects the local and global environment. Application of bio-slurry increases soil structure and fertility, and reduces the need for application of chemical fertilizer.
- *Target 9: Integrate the principles of sustainable development into country policies and program and reverse the loss of environmental resources.*
- Large scale domestic biogas programmes positively influences national policies on sustainable development (e.g. agriculture, forestation, poverty reduction)
- Biogas programmes usually comply with and support government policies and programmes that have positive environmental impacts including pollution control, green house gas emission reduction and forestation
- *Target 10: Halve the proportion of people without sustainable access to safe drinking water and basic sanitation.*
- Biogas reduces fresh water pollution as a result of improved management of dung.
- Connection of the household toilet to the biogas plant significantly improves the sanitary conditions in the farmyard therefore reducing the risk of water contamination.