



# ***Biogas Digest***

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## Table of Contents

Biogas technology in Bangladesh .....	3
Geography, population and agriculture in Bangladesh .....	3
Biogas technology in Belize .....	5
Geography, population and agriculture in Belize.....	6
Biogas technology in Bolivia (region Cochabamba) .....	8
Geography, population and agriculture in Bolivia (region Cochabamba).....	8
Biogas technology in Burundi.....	10
Geography, population and agriculture in Burundi.....	11
Biogas technology in China (Sichuan) .....	12
Geography, population and agriculture in China (Sichuan) .....	13
Biogas technology in Columbia .....	15
Geography, population and agriculture in Columbia .....	16
Biogas technology in India .....	17
Biogas technology in Orissa (India) .....	18
Geography, population and agriculture in Orissa (India) .....	20
Biogas technology in Sangli (India).....	21
Geography, population and agriculture in Sangli (India).....	22
Biogas technology in the Ivory Coast (region of Korhogo).....	25
Geography, population and acriculture in the Ivory Coast (region of Korhogo).....	26
Biogas technology in Jamaica .....	28
Geography, population and agriculture in Jamaica.....	28
Biogas technology on Java (province of Central Java) .....	29
Geography, population and agriculture on Java (province of Central Java) .....	30
Biogas technology in Kenya .....	32
Geography, population and agriculture in Kenya.....	32
Biogas technology in Morocco (region of Souss-Massa).....	34
Geography, population and agriculture in Morocco (region of Souss-Massa) .....	35
Biogas technology in Nepal .....	37
Geography, population and agriculture in Nepal.....	38
Biogas technology in Tanzania .....	40
Geography, population and agriculture in Tanzania .....	42
Biogas technology in Thailand.....	44
Geography, population and agriculture in Thailand .....	44
Biogas technology in Tunisia (Sejenane, El Kef) .....	46
Geography, population and agriculture in Tunisia (Sejenane, El Kef) .....	46
Biogas technology in Vietnam.....	48
Geography, population and agriculture in Vietnam .....	49

## **Biogas technology in Bangladesh**

### **Potentials of biogas**

Cattle dung available from 22 million cows and buffaloes is nearly 0.22 million tons. One ton of dung can produce 37 m<sup>3</sup> of biogas. Available cattle dung can produce 2.97 x 10<sup>9</sup> m<sup>3</sup> of gas which is equivalent to 1.52 x 10<sup>6</sup> tons of kerosene or 3.04 x 10<sup>6</sup> tons of coal.

Besides, a substantial amount of biogas can be produced from human and other animal excreta, garbage and water hyacinth.

### **Biogas utilization**

The first biogas plant (floating dome type) was constructed in 1972. Till now (1997) there have completed around 6000 biogas plants in Bangladesh. The Local Government Engineering Department (LGED) aims setting up 10,000 digesters over the next three years.

In Bangladesh biogas is a proven technology. The plants constructed under Slum Improvement Project (SIP), could show a very encouraging result. This technology now deserves attention to the Government. It is suggested to create a biogas cell, that will monitor the biogas activities. Field level staffs of these departments will be trained on biogas technology. All commercial Banks will ensure loan for the construction of biogas plants. On recommendation and assurance of supervision by the biogas cell. Some private organisations also may be encouraged to make up the responsibility. In order to extend biogas program, it is suggested that based on field information biogas cell is to supply design. The work must be supervised by some trained engineer, who will be responsible for any default.

### **Involvement of Local Government Engineering Department (LGED) in biogas technology**

LGED has been created mainly to provide technical support to the local government institutions. This organization can play an important role in disseminating appropriate technology all over the country as it has setup at Thana level.

First biogas plant based on night soil was constructed by LGED in Faridpur Muslim Mission. Before construction of this plant, there was an apprehension about its acceptability. But after completion of the plant there was no social and cultural barrier. This plant could draw attention of all concerned.

Small bore sewerage system, in conjunction with biogas plant installed by LGED in Bauniabad slum in Dhaka proved to be cheaper and better solution for sewage disposal. Solid waste and water hyacinth based biogas digesters of LGED also created great interest among users.

LGED has trained a lot of professional engineers on biogas technology, some of them received higher training in China.

## **Geography, population and agriculture in Bangladesh**

### **Geography and population**

Bangladesh is one of the most densely populated countries in the world having a total population of 120 million in an area of 147570 km<sup>2</sup>. Over 80 percent of the people live in the rural areas. The majority of the rural people remain unemployed for at least some month of the time. More than half of the rural people are landless or nearly so and another 25 percent find it difficult to ensure subsistence from their cultivable land and need to seek supplementary sources of income. Economic and social conditions for most people are extremely difficult.

## **Economy and agriculture**

Agriculture remains the largest sector of the economy occupying three-fifths of the employed labour force and producing nearly half of the economy's output. Land is the main productive asset in rural areas; it represents both economic and social status.

# Biogas technology in Belize

## History

The first project of the *GTZ* concerning the biogas technology in Belize started in 1988. It evolved from a Caribbean biogas dissemination programme of the *GTZ* which was carried out with the *Caribbean Development Bank*. Biogas consultants and biogas technicians active in the region constructed three **floating-drum plants** of the **BORDA model** within the *Caribbean Technology Consultancy Services* (CTCS).

Since neither the market forces could take up biogas technology, nor could independent dissemination structures grow, the programme was continued in 1989 along the lines of experience gained during biogas activities in the Caribbean and Nicaragua - to anchor biogas-specific, national know-how in a local dissemination structure. On the basis of this background experience and with the financial, personnel and material support of the *Caribbean Biogas Dissemination Programme*, a German under local project contract and, in the meantime, a Belizian have been employed in Belize to build up such a structure in cooperation with the state *Central Farm* and to demonstrate the high performance and efficiency of biogas technology with users. The leitmotif of this involvement which found striking resonance in the socio-economy reality of Belize was:

- 1) The fastest possible transfer of knowledge to the productive sector
- 2) To induce demand extensively independent of external financing
- 3) To anchor biogas technology in a dissemination structure which would support itself.

To modify the technology, to provide practical demonstrations and to train local masons the construction of six **fixed-dome** and three floating drum plants was begun with the assistance of regional experts from Guyana, Nicaragua, Jamaica and other Caribbean islands at two biogas workshops. For larger pig producers, plants were built with the aim of reducing the pollution of surface water. Building five plants for institutions was to

- a) increase awareness of biogas technology and
- b) open the technology up to other areas of application (e.g. wastewater treatment).

An active demand was to be created by means of intensive advertising integrating those active in rural development and with intensive customer advisory services. By linking state interest, social involvement and economic dynamics the dissemination structure was to survive the period of external financing and sustainably anchor and disseminate biogas technology in Belize.

## CAMARTEC model

In 1991 the **CAMARTEC** model was introduced. In comparison to the high input of material and work in plants used previously (reinforced steel vault and fundament), a cost reduction of approx. 15 - 20% was achieved. Since 1993, 20 plants have been built (of these, 5 are institution plants, 13 household plants and 2 are middle-sized plants).

## Target group

The target group for the household biogas plants has so far consisted of farmers involved in commercial pig production. The majority of biogas users own 5 - 40 large pigs. The remaining pig breeders can hardly be considered as a target group: the insufficient number of pigs, inferior sties and only marginal integration into the market means that these can only be considered in particular cases for biogas utilisation. The users so far normally produce peanuts, maize and beans on cropland of between 3 and 10 acres. Until the construction of the plants, the use of organic fertiliser was uncommon. Plant nutrients are usually provided by means of slash and burn methods, and chemical fertiliser in small quantities.

## **Government**

Biogas technology has a good reputation on the governmental and administrative (mostly *Ministry of Agriculture*) levels responsible for it. This good reputation has resulted in significant financial involvement for the small country of Belize. In 1992, B\$ 62,000 were made available for biogas dissemination and with this, the budget was taken which was financed to 50% by the *Caribbean Development Bank* in 1991 (budget MoA 1991: B\$ 53,000) was taken over. The current budget provides for 3 established posts for the *Biogas Office of the Central Farm*.

The government classifies biogas technology particularly as part of its efforts to improve rural infrastructure (decentral energy supply) and to substitute imports (substitution of fossil energy sources). The aspect of fertilising has only been considered a side-effect of biogas technology so far.

## **Geography, population and agriculture in Belize**

### **Geography**

Belize, the second smallest state of America (22,695 km<sup>2</sup>) borders to the north on Mexico, to the east and south on Guatemala. Belize, apart from the northern part of the country, lies in the tropics and is exposed to the northeast trade winds bringing high humidity the whole year around. The rainy season (May to November) and the dry season over the rest of the year are clearly defined. The mean annual precipitation in Belize City amounts to 1890 mm and is distinctly higher in the south. The monthly mean air temperature here in the coldest month (January) is 24.1°C and in the warmest (August) is 28.8°C. It is estimated that approx. one third of the land is suitable for agriculture although in 1985 only 101,000 hectares were stated as being agricultural land.

### **Population**

The total population of Belize is estimated today to be approx. 200,000. The demography of Belize shows the following characteristics:

- an even distribution of rural and urban population
- significant emigration of young adults abroad
- an ethnic cross-section comprising descendants of three Maya groups (Yucatec, Kekchi and Mopan), Garifuna (Black Caribbeans), Europeans (Mennonites), Creoles, Mestizas and immigrants from the Near East.

This ethnic cross-section has a considerable influence on the agricultural sector.

### **Economy and agriculture**

The economy of Belize is marked by high dependence on imports and a small domestic market. Amongst other things, this results in high sensitivity to fluctuations in the world economy and in a trade deficit of approx. 50 million US\$ annually. Due to low industrial production which only makes a 20% contribution to the national income (including the agroindustry), agriculture remains the most important economic factor in Belize. It makes a contribution of 21% to the GDP at factor cost (1986). In 1984 this included approx. 32.1% of the workforce.

Until the 20th century agriculture was dominated - as the national economy of Belize also was - by forestry which had a sustainable effect on the structure of agriculture. The cultivation of sugar cane (followed by citrus fruits) has been able to develop into the most important source of foreign currency in recent decades due to special agreements with Great Britain yet stable commercial structures have only been able to establish themselves beside this export sector to a limited extent in the agricultural sector. Smallholders (Milpa farmers) with only a weak capital background and low market integration represent three quarters of agricultural producers. In 1971, 74.6% of farms had less than 21 acres. With slash and burn

methods they clear the land for the cultivation of rice, maize, beans, fruits and vegetables as the main produce but also some animal husbandry, chiefly pig production is carried out.



## **Biogas technology in Bolivia (region Cochabamba)**

### **History**

In 1986, the GTZ, in cooperation with the *Universidad Mayor de San Simon* (UMSS) in Cochabamba began a project to disseminate biogas technology. Until 1989 these activities were part of the supra-regional GTZ *Biogas Dissemination Programme*. From January 1990 to the end of 1992 the biogas activities were continued as a component of the *Bolivia Special Energy Programme* started at that time.

By consolidating biogas technology into the Departamento Cochabamba and into the general background of national energy and landscape planning by means of the *National Biogas Network*, the aim was to integrate "biogas technology into the agricultural production process" so that the "destruction of agricultural ecosystems" could be curbed and "energy and organic fertiliser" could be produced decentrally. 27 plants, 9 of them in the Cochabamba area, were produced by varying measures carried out by varying organisations and of which only 1 was still functioning in 1988.

In a development policy respect, the project was seen at that time to provide access for the economically weaker groups of the population to biogas technology and to improve their general economic situation. In 1988 the project purpose was defined to be "the creating of fundamentals on which to extensively disseminate biogas technology through Bolivian institutions by carrying out training and building demonstration plants". Credits, training and the improvement of project management were to allow a high-performance dissemination structure. Here, one emphasis was placed on the integration of the technology into local, regional and national socio-economic structures and on the dissemination of the so-called "Integrated Farming Systems". The biogas plants were mainly understood in this connection as "fertiliser plants" which make a contribution to strengthening intensive animal husbandry and to supporting agricultural production.

In the knowledge that the project regions of higher altitude were unsuitable for biogas dissemination, the *Biogas Office* concentrated more and more on the migrational regions in the tropics with an inferior infrastructure. Here, approx. 35 plants were built between 1989 and 1992.

A survey carried out by the *Biogas Office* has identified interesting potential, particularly in Santa Cruz, in the field of industrial and communal sanitation. After having built a UASB (upflow anaerobic sludge blanket) plant for the Palmasola prison the attempt is now being made to establish consulting in the field of anaerobic wastewater treatment. At the time of the survey this target was endangered because of missing a budget, unclear legal status and only partly consolidation of the *Biogas Office* on the demand and supply level.

## **Geography, population and agriculture in Bolivia (region Cochabamba)**

### **Geography and population**

The geographical zones in Bolivia are tropical and subtropical lowlands, upland valleys and hilly areas and the Altiplano situated at 4,000 m above sea level.

The region Cochabamba extends over upland valleys as well as over tropical lowlands. It consists of 14 administrative regions. Including the districts of Carrasco and Chapare located in the tropical regions it comprises an area of 55,631 m<sup>2</sup> in total. According to the 1976 census Cochabamba Valley, lying at an altitude of between 2,300 and 3,700 m, has a population of 730,358. The province capital, Cochabamba (location of the project, 2,553 m above sea level), with 377,000 inhabitants is one of the economic and commercial centres of the country. The Cochabamba Valley is divided up into the districts Valle Bajo, Valle Central, Valle Alto and "Cabecera de Valle". The mean annual temperature lies at around 17.7°C with

night frost occurring in winter. The mean annual precipitation amounts to around 477 mm. Climatic conditions allow arable farming between November and May.

The dissemination region Cochabamba Tropical is approx. 280 km northeast of the city of Cochabamba and comprises 2,500 km<sup>2</sup>. The mean annual temperature is about 24.7°C with temperatures of over 30°C being possible during the day. The south wind "Surazo" can however make temperatures fall to less than 10°C. The mean annual precipitation depending on the area is between 3,500 mm and 6,000 mm. The population amounted to approx. 350,000 in 1989 and lives mainly in scattered settlements, chiefly along the road to Santa Cruz. The region is a migration area and has been developed for approx. 20 years mainly by migrants from the highlands of the Andes. The population development is strongly dependent on the development of coca cultivation. A substantial share of the national coca production which made a contribution of 600 million US\$ to the GNP in 1990 comes from here. With the decline in the price of coca and restrictions in its cultivation in 1990 the population promptly fell to approx. 91,100.

Demographically the population comprises approx. 30% Mestizas, 25% Quechuas, 17% Aymarás, 12% Europeans (and Americans) and "others".

### **Economy and agriculture**

Bolivia is considered to be one of the most politically and economically unstable countries in South America. The economy of Bolivia grew between 1987 and 1990 by approx. 2.5% annually. However this growth could not close the gap in the economic structure of Bolivia which separates the Indio population from the white population, i.e. the urban from the rural populations, and which makes the informal sector (approx. 60% of inhabitants working in cities are active here), superior to the formal sector (mainly from the export of coca) also under the aspect of added value.

Agriculture is ascribed - now that mining has lost its key position - with a substantial potential for development, in particular if a South American economic area is to be formed. Especially the Amazonas region around Santa Cruz is seen as the central agroindustrial growth area. In 1990 cattle to the value of 50 million US dollars were exported from this region. Where energy is concerned, Bolivia is independent of imports. Marketing of oil and gas energy resources on the domestic market brought 452 million US dollars in 1989. This year, the revenue from energy imports amounted to US \$ 214 million. This corresponds to 26% of the total amount of exports.

# Biogas technology in Burundi

## Biogas Dissemination Programme

The Projet Biogas is under the control of the *Ministry for Energy and Mining*. The project was initiated as a *Biogas Dissemination Programme* of the *GTZ* in 1984 in the region Cankuzo, it has been part of the *Special Energy Programme* since 1988.

## History

The first agricultural family plants were constructed on livestock farms in the region of Cankuzo in 1985. In 1987 the project was extended to include the Ruyigi region. At the same time the building of biogas plants started for the toilets of schools and other institutions. Private contractors were commissioned for larger plants. The training of craftsmen, the establishment of a service system and the opening of material credit funds were to provide the basis for a self-reliant dissemination concept. By 1992, 206 small-scale plants, and 84 institute plants with digester volumes of over 100 m<sup>3</sup> had been constructed.

## Plant type

Technically, the basis was on the masoned **fixed-dome plant** modelled on the Chinese design from the outset. Large digesters were chosen on account of the relatively low temperatures in the digester of just over 20°C so that longer fermenting times could be achieved. Gas production was an average of about 0.1 m<sup>3</sup>/m<sup>3</sup> per day.

Experiments with slurry as fertilizer were carried out from the outset on land belonging to the project and to communes. Permanent stabling with grass production as fodder was propagated in cooperation with other institutes.

The directorate general for energy in the Ministry set up a committee to coordinate all biogas activities in the country. The focal area of work in the project is today centred on the construction of plants for institutes, particularly for schools during which the major aspect considered is the environment. There is close contact with *the Ministry of Education*.



View in a canal digester, Burundi

Photo: Mang

# **Geography, population and agriculture in Burundi**

## **Geography**

Located in the eastern part of Central Africa, Burundi with 28,000 km<sup>2</sup>, is one of the smallest countries in Africa but with 192 inhabitants per km<sup>2</sup> it is also one of the most densely populated. Large expanses of the country are hilly to mountainous with average altitudes of between 1400 and 2200 m above sea level. The southern part near to Lake Tanganyika where Bujumbura, the capital city, is located is flat and is at an altitude of approx. 800 m above sea level. The climate is tropical here. At approx. 3° south of the equator, the seasonal differences in climate are slight, the rainy and dry seasons show comparatively little difference. Normally, precipitation is sufficient and allows arable farming throughout the year.

## **Population**

94% of the population (about 80% Bantu, 14% Hamites) live in the rural areas, the degree of illiteracy is 50%, the GNP amounted to approx. 210 US\$ per capita in 1990 and increases annually by 3.4%.

## **Agriculture**

Agriculture contributes to 56% to the GDP. It is divided into an export-oriented sector (coffee, cotton, tea etc.), a sector which produces for the local market and subsistence farming from which about 90% of all agricultural products come. Approx. 27% of the country is used for extensive livestock farming (mainly cattle). The remaining area is inhabited mostly by smaller farmers with an average of only 0.85 hectares and hardly any livestock apart from a few goats.

## **Energy**

The commercial consumption of energy amounted to the equivalent of 21 kg mineral oil in 1990; only 1% of exports accounts for the import of energy. The main source of energy is wood or charcoal which has led to alarming deforestation and subsequent erosion. The supply of hydro-electric power is limited to the cities; apart from this, a number of institutions and economic enterprises operate their own generator stations driven by diesel.

# Biogas technology in China (Sichuan)

## History

The first household biogas plants were installed by well-off families in the forties. However, biogas was not propagated or promoted extensively until around 1970. After a phase of massive campaigns some million biogas plants were constructed, but these only functioned to a minor extent due to technical defects. The focal point of biogas dissemination was the province of Sichuan, and here especially the area around Mienyang. Due to climatic conditions, biogas only played a less significant role in Northern China. Biogas plants spread most rapidly in areas where politicians particularly devoted themselves to this task and in areas whose traffic infrastructure was well developed and which were not, in fact, among the poorest of regions.

The interaction of the three levels, state, cooperative and household was a favourable atmosphere for the dissemination of biogas in periods of a strongly socialist tendency. The state provided the skeleton conditions, the cooperatives or communes provided material and paid for the labour for the otherwise private biogas plants. On the user side also there was hardly any coalition of interests between communes and cooperatives. This very interesting interaction of varying levels has ceased since the introduction of privatisation. For example, since privatisation straw is far less frequently used in the biogas plants as emptying of the plants involving a high work input no longer becomes necessary because the digested straw no longer has to be provided for use on communal fields as it had to be during times of communal management.

Since 1982 obligatory standards have been prescribed and applied in the construction of biogas plants. At the same time, the aggressive dissemination strategy has been cut back, scientific research has been intensified and direct subsidies have been reduced. Since subsidies were abolished the number of plants built annually has slumped. In Sichuan, in 1992 there were around 1.7 million biogas plants in operation.

## Dissemination structure

Biogas dissemination is integrated into the administration structure of the *Ministry for Agriculture*. Local biogas offices are the reference points for farmers. It is here where they receive advice and where they commission the biogas plant. Technicians supervise the construction of the plant which is carried out by private companies which, in some cases have specialised in biogas plants. Costs for labour and material are borne by the farmers. The gas appliances are purchased against payment in the biogas offices.

## Subsidies

Direct subsidies have been abolished but in some individual cases the farmer receives allowances from an *Agricultural Supporting Fund* or from state enterprises which have taken over sponsorship of biogas plants or which employ owners of plants.

## Types of plants

In the biogas offices four sizes of standardised plants are offered; the most frequently built are plants with 6 m<sup>3</sup> digester volume. These are **fixed-dome plants** which are either concreted or are fixed domes built of bricks according to the availability of materials locally. The pipe connected to the compensation chamber is at medium height. Such details and similar matters have been scientifically investigated over many years and finally standardised.

## Strategy of biogas dissemination

According to high-level biogas officials, the strategy of biogas dissemination is based on the recognition that biogas plants are important in saving energy, in improving agriculture and in the protection of the environment. However, it is assumed that these overriding objectives are of little significance for the potential owner of the plant in his decision to invest. It is for

this reason that an increase in income, by intelligently integrating the biogas plant in the production process, is emphasised as the incentive for investment. The greater role here is played by the utilisation of slurry. Consequently, production processes involving the use of the slurry for the cultivation of edible fungi, for fish farming, pest control or as pig food are propagated which thus increase the value of the subsequent products. The use of human nightsoil as substrate is, of course, a condition of this, and in fact, it is practised in 80% of all cases.

### **Further reading:**

A summary on the technical development is given by Cao Guo-Qiang (Overview on Biodigester Development in China, BIOGAS FORUM No. 48). An interesting case study by Hu Qichin on the rural district of Xindu (published by AIT Bangkok, 1991) describes, in addition to many details, the drastic decline in demand in recent years.

## **Geography, population and agriculture in China (Sichuan)**

### **Geography and population**

The province of Sichuan is in the southwestern part of the People's Republic of China and has an area of 570,000 km<sup>2</sup> with a population of 87 million people. Sichuan is one of the most fertile areas in China.

The rural districts of Minxhu, Dujian and Xindu lie around 20 - 70 km north of the province capital Chengdu. Xindu and Dujiang are on a plain about 500 m above sea level whereas Minxhu is at the foot of the eastern Himalayas and comprises flat as well as mountainous country.

### **Agriculture and economy**

The climate here is continental; temperatures are between -10° and +40°C although mostly between 16° and 18°C. Rain falls evenly with slight fluctuations throughout the year. Two harvests per year are possible for which rice and wheat are often grown after each other. In addition to cereals, oilseed is also produced. The banks of irrigation channels are lined with mulberry bushes used for the culture of silkworms. Any other free spaces are used for growing vegetables; water cabbage grows in stagnant waters. The growth of trees is restricted to avenues and riverbanks; Bamboo bushes often surround the houses. There are scattered and linear villages as well as scattered settlements.

About 20% of farmers have other income from cottage industry, trades and crafts in addition to their earnings from agriculture. The women normally attend to the household and the farm whilst the men follow a non-agricultural profession. Every household has less than 1 hectare of land at its disposal. The annual per capita income of the rural population amounts to 600 - 650 yuan (110 - 120 US\$). In comparison, a bricklayer earns relatively well with 150 yuan per month.

China is currently undergoing radical change from a collective economy with planned targets to a free market economy. Modernisation within industry is being given first priority in development planning. Rural communes have been abolished since the mid-eighties and the land has been given to the farmers for private utilisation. Despite this, the state still partly controls the sale of staple foods through purchasing cooperatives. Only products in excess of compulsory levies or which have been approved can be sold on the free market.

In contrast to wide areas of Northern China there have never been such huge sized fields of arable land in Sichuan. Agriculture is based on family farms supported by purchasing and selling cooperatives. The producers of and selling prices for staple foods are fixed by the state. High meat prices are to increase the production of pork. Organic fertilizers are promoted as important but parallel to this the state is pushing forward the production of chemical fertilizers.

## **Energy and environment**

The supply of coal, natural gas, electricity and even wood fuel continues to be subject to state control and planning. The main source of energy with a share of 73% is coal which is mostly used in the form of briquets. The use of renewable energy including biogas is subsidised indirectly in that the state provides the essential infrastructure and finances research.

The significance of environmental protection has been recognised on government and administration levels. Keeping water clean and careful use of pesticides etc. are matters which are being promoted or have already been formulated into laws. The observance of these, however, is not guaranteed everywhere, mostly for economical reasons.

# Biogas technology in Columbia

## Special Energy Programme Columbia

In May 1985 the *Special Energy Programme Columbia* located in Barranquilla began work. This resulted in the project concept "investigation of the possibilities of producing and using biogas" in the Valle de Cauca. A German consulting company (*Oekotop*) was commissioned with carrying out the project as a subcontractor. The executing organisation on the Colombian side was the *Corporación Autónoma Regional del Cauca* (CVC). A German long-term expert was active locally within the project from November 1985 to April 1987. Another long-term expert was involved from November 1987 until the contract with the consulting company ended in March 1989. During this period, the central problem was the "pollution of water resources"; the project purpose was to "disseminate modified biogas technology". Until this time, the activities within the project were marked by a great deal of research and development. Investigations were also carried out into the use of slurry.

From November 1989 to the beginning of 1992, a new consulting company (*BioSystem*), closely related in a personnel aspect with the original company, was commissioned with implementing a further project phase. During this time in which a "contribution to the improvement of the rural energy situation and the conservation of water resources by the use of biogas plants" was to be attained, another long-term expert was involved locally. This phase was marked by efforts to demonstrate the efficiency of biogas technology under dissemination conditions. I.e it was mainly a rehabilitation programme for non-functioning plants and set up a central area for a dissemination structure. The building of demonstration plants on selected farms was to establish biogas technology in the rural region. The involvement which was planned in the agro-industrial sector was suspended due to its complexity (initial investigations on the fermenting of agro-industrial wastewater had been carried out). Between 1985 and the beginning of 1992 a total of 25 biogas plants were built.

## Types of plants

A **floating-drum plant** of the **BORDA type**, a **tunnel plant**, various **fixed-dome plants**, a **balloon plant** and a UASB (upflow anaerobic sludge blanket) plant were built during this time. The type of plant was standardised in 1988. When the project was handed over in 1992 this consisted of 4 fixed-dome plants of 14 to 48 m<sup>3</sup> and three fixed-dome plants of between 67 and 115 m<sup>3</sup> with a separate gasholder.

In line with the heterogeneity of biogas users' agricultural household and farm systems, the integration of biogas technology into agricultural and farm systems was very varied. The plants were mainly built for medium-sized and larger pig and cattle breeders who had between 20 and 2,000 head of animals. The heterogeneity of the farms was also reflected in the pattern of utilisation and the condition of the plants.

## Farm management

Especially farm management had a considerable influence on the degree of effectiveness of biogas technology. The plants were normally filled by labourers. The administrator played a central role in instructing the staff in the function of the biogas plants due to the high rate of staff fluctuation in some cases. An extensively constant solids content i.e. the separation of long-fibred material (scum formation) is important for the ability of the biogas plant to function. Scum formation and the washing out of substrate could be observed on some plants. Especially uncontrolled inflow of washing water confronts conventional fixed-dome plants with "digestive problems". Labourers who were not instructed sufficiently and were not bothered, washed out the stables with large amounts of water which resulted in drastically reduced retention times. Adequate attention to the plants is impeded by different staff involved in filling and in using the gas. Not the workers, but the owner of the Finca or the administrator profits from the gas. Without the "long arm" of the farm management, proper filling and thus reliable function of the plant is not possible.



# **Geography, population and agriculture in Columbia**

## **Geography and population**

Columbia can be divided into several climatic zones. The regions on the Caribbean and Pacific coasts, the river valleys, the eastern plains and the Amazonas areas show mean annual temperatures of over 24°C. Temperatures in the Andes fluctuate according to altitude.

With a total area of 1,410,784 km<sup>2</sup>, Columbia is the fourth largest state in Latin America and had a population of approx. 30 million in 1988 of which more than 60% are Indians. The growth rate has amounted to 2% during the last ten years. The proportion of urban population is unusually high for a so-called developing country. 98% of the total population belongs to the state Catholic church.

The project region comprises the Valle de Cauca between the central and western Cordillera and borders on the Pacific Ocean. The valley covers an area of 2,200,000 hectares of which 326,983 hectares are administrated by the Departamento de Valle and 99,875 hectares by the Departamento Cauca. The Cauca river flows through the Cauca valley and is fed by numerous tributaries flowing down from the mountains through river valleys - so-called Cuencas. The annual precipitation is subject to great fluctuations of between 1,000 mm and 2,000 mm annually. The mean annual temperature amounts to approx. 23°C but can be considerably lower in higher mountainous regions.

## **Agriculture and economy**

Considering its natural conditions, the region has a substantial potential for agricultural development. 35% of the soils are among the best in the world. Today, the region is marked by sugar-cane cultivation. In 1983, sugar-cane was grown on 400,000 hectares. 13 of the 14 Colombian sugar-cane processing companies are located in the Valle de Cauca. In 1983 they produced 1,340,190 tons of sugar.

Although Columbia has substantial natural resources the economy was dominated by coffee production for many years. With the decline of coffee prices and the increase in the production of oil, oil became the main source of income for the country in 1990. Orientation towards exports overshadowed domestic production in the agricultural sector for a long time so that in 1990, 309 million US\$ worth of foodstuffs had to be imported. Nevertheless, beef production has been falling in recent years due to declining profit rates. On the other hand, there has been positive development in fowl production.

The economic situation of farms in the agricultural sector is very varied. Poor farmers hardly have access to modern means of production. The farmer himself is often forced to improve his income situation by labouring. 62% of rural landowners have between 0.5 and 5 hectares which constitutes only 5% of the total land owned.

According to estimations by the Insitituto Colombiano Agropecuario, the number of pigs in Columbia currently amounts to approx. 2,300,000 and the number of cattle to approx. 22.7 million. Intensive and modern methods of animal husbandry have only spread during recent years. In the south of the Valle de Cauca, there are approx. 180 medium-sized and large pig breeders with an average of 270 head, in the north there are 94 pig breeders with an average of 100 pigs (a total of 5,636 pig breeders was recorded for Valle). A survey carried out by an expertise commission in June 1992 recorded 3,702 farms with a sufficient supply of biomass. However, the form of stabling was not taken into consideration during this calculation.

# Biogas technology in India

## History

Biogas technology is being promoted in India chiefly under the aspect of energy. The focus on this derives from the crucial energy supply situation for the population in the country. Besides China, India is the country where the development of uncomplicated biogas plants for the Tropics which are simple to operate started. Since the fifties the mass dissemination of biogas plants has been propagated and initiated for rural households, yet this development did not experience an upswing until the seventies so that by 1980 100,000 plants had been installed. With the beginning of the 6th 5-year plan in 1981, the *National Project for Biogas Development* (NPBD) came into being following the objective of mass dissemination of household biogas plants and also including financial support.

Biogas dissemination in India experienced a number of set-backs as a large proportion of the plants erected were not used or only used to an insufficient extent. Reasons on the one hand, were the immature technical properties of plants themselves until the beginning of the eighties and on the other hand, a dissemination strategy which was only minimally developed and which did not recognise the importance of user training and follow-up services until much later. Despite this, biogas technology was constantly supported by the Indian government. In 1982, the newly founded *Department of Non-Conventional Energy Sources* (DNES) as a department of the *Ministry of Power and Non-Conventional Energy Sources* took over central control of biogas dissemination. In the meantime, there are around 1 million household biogas plants in India of which 70-80% are assumed to be in operation.

Biogas dissemination is promoted centrally by the *Ministry of Non-Conventional Energy Sources* (MNES, formerly DNES). This department consults on and resolves the guidelines on financial support for biogas technology, commissions assignments in research and development and decides on the eligibility of new biogas plants for aid. The actual dissemination work is carried out by the governments of the Indian states, the public corporations *Khadi and Village Industries Commission* (KVIC) and the *National Dairy Development Board* (NDDB) but mainly by countless non-governmental organisations. Within the framework of aid prescribed by MNES each state is responsible for the guidelines applicable in its region. The individual provisions prevailing thus vary from state to state.

## Types of plant

A total of seven different types of biogas plant have been officially recognised by the MNES. These are:

- a) the floating-drum plant with a cylindrical digester (KVIC model),
- b) the fixed-dome plant with a brick reinforced, moulded dome (Janata model)
- c) the floating-drum plant with a hemisphere digester (Pragati model)
- d) the fixed-dome plant with a hemisphere digester (Deenbandhu model)
- e) the floating-drum plant made of angular steel and plastic foil (Ganesh model)
- f) the floating-drum plant made of pre-fabricated reinforced concrete compound units
- g) the floating-drum plant made of fibre-glass reinforced polyester.

Only these types of plant and only when they do not exceed a nominal gas production of 10 m<sup>3</sup> per day (i.e. approx. 30 m<sup>3</sup> digester volume) can apply for subsidies paid by the central government. This provision however, is interpreted by the governments of the Indian states and by local administration bodies so that in individual states completely different types of plants can quite often be defined by the relevant authorities to be one of the officially recognised types.

## Promotion of biogas technology

The most important instrument in the promotion of biogas technology is the provision of allowances paid towards the investment costs which is of direct benefit to the farmers. Everyone in India installing a biogas plant has the right to an allowance paid by the central

government. The extent of this sum is defined by the size of the plant, the social category the user belongs to and the relevant part of the country where the plant being promoted is located. India has been roughly divided into three areas according to the average altitude: according to this, the highest allowances are paid in the mountainous northeastern region; the second category includes hilly regions or ones of high altitude in other Indian states. The remaining states are covered by the third category. Here, the allowances depend on social categories: non-caste Hindus, members of the lower castes (scheduled castes), tribes (scheduled tribes) and the category of smallholders. Marginal farmers and those owning no land receive higher allowances than farmers in the general category which includes all farmers who do not belong to any of the social categories stated but who have more than 5 hectares of land.

In addition to direct allowances for investment costs, the states and private biogas dissemination organisations reaching an annual planned target of more than 8,000 plants receive 2.5% of the total amount of construction as an allowance towards establishing and maintaining an organisational infrastructure. This promotion called "service charge" amounts to 5% for dissemination programmes with a planned target of below 8,000. One half percent of this "service charge" must be allocated to establishing follow-up services, monitoring and evaluation, the compilation of material for public relations work and to gratuities for staff who deserve these.

More informations on provinces of India:

## **Biogas technology in Orissa (India)**

### **Dissemination structure**

The promotion of biogas technology declared by the central Indian government as a key programme is also expressly followed by the state government of Orissa. The central coordinating authority is the *Orissa Renewable Energy Development Agency* (OREDA) which defines the directives for promotion by the state and organises the distribution of funds provided by the central government. Apart from this, OREDA also appears as a dissemination agency. In many districts of the state there are dissemination offices equipped with technical staff who are charged with building biogas plants. An important function of OREDA is the approval of "turnkey operators". These are organisations who build biogas plants commissioned by the government and receive the state subsidies granted to builders by the central government for each newly built or repaired biogas plant. As a result of bad experience with the quality of building and insufficient follow-up service carried out by private biogas entrepreneurs these are exempted from state subsidies in Orissa.

The main objective of the organisation is to promote the development of the non-Hindu peoples in various districts of Orissa. Measures comprise the provision of basic health services, the promotion of self-help organisations on a village level, the combating of illiteracy, support of self-help groups for selling and credits, promotion of women's groups, the establishing, care and utilisation of village community forests. The dissemination of biogas plants constitutes a central point itself and also includes the Hindu population.

### **Gram Vikas**

*Gram Vikas*, an Indian organisation, has been involved in the dissemination of biogas in Orissa since 1981. Biogas dissemination has established itself as the most comprehensive activity within the organisation in recent years. *Gram Vikas* in the meantime has become the most significant disseminating organisation in Orissa and, in addition to this, has become one of the largest and most successful biogas organisations in India. Annual output amounts today to nearly 10,000 biogas plants per year. A total of 42,000 plants - this corresponds to about 3% of all Indian biogas plants - were disseminated by *Gram Vikas*.

The structure of *Gram Vikas*' organisation for disseminating biogas mirrors the structure of public administration in Orissa. *Gram Vikas* disseminates biogas plants in 9 of 13 administrative districts i.e. in 170 of a total of 314 blocks. According to the basic principles of their work, these are mainly the areas with a high percentage of indigenous population. The

allocation of the regions of the state for dissemination is decided in annual negotiations with another large dissemination agency, the state-owned OREDA. Apart from these two organisations the *Block Development Officers* (BDOs) in state block administration also carry out biogas measures.

Whilst the upper two levels carry out general administration, acquisition of funds and material and the supervision, the actual construction work is mostly organised by the *Block Dissemination Offices*. The Sub-division Coordinators assist in and supervise the work of the *Block Dissemination Offices* by purchasing and allocating building materials and accessories and visiting individual customers after conclusion of the work. They also document the work within the Blocks and compile this for Programme Coordinators on a district level.

## **Masons**

The masons are not taken on as employees as building work almost comes to a complete standstill during the monsoons. Biogas plants are mainly built between the months of March and June for this reason, i.e. prior to the monsoons when the groundwater level is at its lowest, when locally made bricks are available and when very little work can be done in agriculture. The masons are paid on a daily basis; in 1992 a biogas mason earned around Rs 40 (= DM 2.66) per day and was thus paid in line with masons in other fields.

Salaried employees on a block and district level are instructed to use the out-of-season time to carry out follow-up service of the plants. This involves not only visiting and inspecting biogas plants built by the organisation but also those which are more than 2 years old and whose guarantee has run out. Visits to newer plants are also used to make the users familiar with the operation of the plant.

## **Guarantee period**

Within the guarantee period of two years repair becomes necessary for about 5% of the plants. Since the government provides no funds to subsidise repair work within the guarantee period, the costs directly affect the overheads of the organisation. The risk of having to rebuild only a single biogas plant with a total value of RS 5,000 means using the state subsidy of Rs 400 per plant for approx. 13 new plants. Quality assurance is thus a particularly important aspect of dissemination management.

## **Women**

Farmers' wives are ascribed a key role in the acceptance and efficient utilisation of biogas plants. For this reason there are mobile teams consisting of three women in each in various districts whose specific task it is to motivate farmers' wives to use the biogas plants accurately and to train these in the operation of the plants and in the use of the gas.

## **Utilisation of slurry**

The utilisation of slurry has not been an express element of training in the past. It is tradition to collect the dung in the South of Orissa, dry it in the sun and then to spread it on the fields shortly prior to the vegetation period when preparing the land. Composting dung is unfamiliar to many biogas farmers, and in most cases, the slurry out of the biogas plant is dried. When farmers have a kitchen garden or irrigation systems the slurry is used in a liquid form.

## **Types of plant**

The majority (87%) are **fixed-dome plants** of the **Deenbandhu type** with a digester volume of around 6 to 9 m<sup>3</sup>. However, there is a tendency towards an increase in the proportion of smaller 6 m<sup>3</sup> plants; in 1990 to 1991 these alone made up 84% of all newly built plants. As interpreted by Gram Vikas this reflects more specific aiming at poorer target groups and the increasing technical perfection and professionalism in plant construction. As the plants rarely still have problems with gas leakage in the masoned dome, smaller plants are now sufficient to meet the energy demand of a family. Investment costs for a turnkey plant of this size amount to Rs 5,800 (= DM 386) of which the material costs make up the greater part.

## **Dissemination costs**

The high overall costs in dissemination can be justified if they are compared with the costs of alternative energies. In its annual report for 1990-91, *Gram Vikas* compares the performance and the costs of the 39,000 biogas plants built between 1982 and 1991 with the investments necessary to generate the same amount of thermal energy. The calculation is as follows: assuming that 80% of the plants are operated with 60% of the performance theoretically possible, daily gas production amounts to 47,586 m<sup>3</sup>. This corresponds to the thermal generation of 4,079.9 million kWh. With the same service life of the plants, assumed to be 25 years, and a price of Rs 1.50 for the generation and distribution of one kWh of electric energy, the investment costs for the generation of electricity amount to 31 times as much (6,119.9 million RS) as the investment costs essential for biogas plants (195.3 million Rs). If the thermal energy required for power generation is used, biogas plants would only be 3.8 times cheaper. The high appreciation of biogas technology is reflected materially in the guidelines and subsidies available to farmers and project executing organisations. It is similarly reflected in how banks integrate biogas into the promotion of credits.

## **Geography, population and agriculture in Orissa (India)**

### **Geography**

The Indian state of Orissa lies in the eastern part of the subcontinent. The coastline of the Gulf of Bengal forms the eastern border; states bordering on Orissa are Madhya Pradesh to the west, Bihar and Bengal to the north and Andhra Pradesh to the south. The geographical area of the state comprises 156,000 km<sup>2</sup>. The climate is tropical with hot summers and temperatures of up to 45°C and mild winters with minimum temperatures of around 15°C. Orissa lies on the route of the southwest monsoon bringing a marked rainy season to this area between June and September with a precipitation of between 1,750 mm. in the south west and the coast and 1,320 mm in the west.

The land comprises a transition from the plateau of the Eastern Ghat in the north to the flat alluvial land on the coastline of the Gulf of Bengal. Three quarters of the region is hilly with maximum altitudes of 1,500 m. Three major river systems rise in the highlands in the north, the Chotanagpur Plateau. The wide branching network of the Brahmani, Baitarani and Mahanadi rivers has produced fertile alluvial land along the coastline to the Gulf of Bengal. 40% of the geographic area can be used for agriculture. The tropical forest which originally covered the whole of the territory now comprises an area of 59,960 km<sup>2</sup> (= 38% of the area) according to official statements; in reality however, only about 16% of the total area can be called forest and this area too is rapidly disappearing due to extensive felling for firewood and building timber.

### **Population**

With an average population density of 169 per km<sup>2</sup>, Orissa is less densely populated than other Indian states. An estimated 32 million people live in Orissa. The state lies in the "tribal belt" of Central India, around 22% are members of non-Hindu tribes. Orissa is mainly an agricultural state: 88% of its inhabitants live in approx. 50,000 villages. 6.4 million people live in towns, the majority of these - 4.6 million or 17% of the total population - in the district Cuttack. The population is predominantly, to approx. 65%, illiterate. The growth rate of the population is 1.9% annually.

Orissa belongs to the least developed and poorest states of India. More than two thirds of the population live below the poverty line. Although this area is rich in iron ore, manganese, chromium, bauxite and coal their mining constitutes only 5.2% of the total raw materials extraction in India. Orissa has over 10% of India's water resources at its disposal (with approx. 4.75% share in the area of the state of India) but only 20% of the cultivation area is irrigated (Indian average: 27%).

## **Agriculture and economy**

Agriculture is the most important source of income for Orissa; two thirds of the state budget is produced by agriculture which employs 80% of the population. The most significant agricultural product is rice; around 7.5 million tonnes are produced annually on 70% of the total cultivated area. The second most important products are leguminous crops taking up more than 20% of the arable area in the state. Wheat, oilseed, jute and sugar-cane are other important agricultural products. About 3.5 million agricultural enterprises are registered by the tax authorities for this state. The average size of farm amounts to 1.6 hectares and is below the average size of farm in other Indian states.

## **Biogas technology in Sangli (India)**

### **Khadi and Village Industries Commission**

Biogas technology is particularly evident in the south of Maharashtra due to the high level of agricultural development. In no other Indian state are there so many biogas plants as here. In 1992 they numbered around 345,000. A significant contribution to this development was made by the *Khadi and Village Industries Commission* (KVIC) whose headquarters are in Bombay. Considerable development work was also carried out by J.J. Patel with the famous Indian floating-drum plant ("Gram Laxmi", better known under the "KVIC Design").

### **Biogas dissemination**

Central coordination of the biogas dissemination in Maharashtra is with the *Department of Rural Development* in Bombay. Subsidies provided by the central Indian government are handled through the *District Rural Development Agencies* (DRDA). The DRDA have the power to decide in their district. A large number of non-governmental organisations and private constructors build and disseminate biogas plants as "turnkey operators".

*Shivsadan Griha Nirman Sahakari Society Ltd*, called *Shivsadan* (Maharati: "house of Shiva") for short, is a commercially run factory for the production of pre-fabricated concrete compound units. The company which was established in 1969 has been building biogas plants since 1976. The initiative for the programme came from the Sangli sugar mill to which Shivsadan has good contacts. At a joint conference of KVIC and representatives of the sugar industry in Bombay in 1975, the sugar industry was called upon to propagate and disseminate biogas plants in its operation areas. Shivsadan states the maximum building capacity to be 4,000 plants per year.

To carry out research and development work, the *Shivsadan Research Foundation, Sangli* was established in 1989 and the *Shivsadan Research Institute, Sangli* (SRERI) connected to this also founded. In addition to applied (commissioned) research in agriculture, technical environmental protection and renewable sources of energy, it is also their task to discover new fields of application for ferrocement and concrete compound units.

### **Target group**

The original target group consisted of cooperative farmers in the sugar industry. 350 plants were built for these in the mid-seventies during a three-year demonstration phase. Since then, the extensive demand for biogas plants has made biogas dissemination the most important branch of production for *Shivsadan*. In many villages where a large proportion of cooperative farmers live, biogas plants are almost exclusively *Shivsadan* plants. According to the company, 15% of all plants in the districts attended to are being built within their dissemination programme. A larger proportion, an estimated 85% of all biogas plants, are masoned **Deenbandhu plants**.

### **Types of plant**

*Shivsadan* offers two types of biogas plant. Besides the classic **floating-drum plant** with a gasholder made of steel sheeting, a newly developed **fixed-dome plant**, called the "**Krishna**

**Model"**, is offered in sizes of 6, 9, 12 and 18 m<sup>3</sup> digester volume. It is marked by a low price and is free from corrosion as all the components are made of concrete.

Components for both types of plant are produced in the Sangli factory, loaded onto lorries and installed at the customer's farm within one day. The lorries are equipped with a crane so that all the work necessary can be carried out by the installation team without them having to obtain any extra machines or aids. Normally the biogas plants are ordered with a connected toilet.

The latest product by *Shivsadan* is a repair set for defective floating-drum plants. Using this, old masoned plants whose gas dome has been removed, can be converted into fixed-dome plants. After the installation of a pre-fabricated concrete part, the plants perform according to the principle of a fixed-dome plant.

*Shivsadan* is the only larger organisation which builds biogas plants in the districts it attends to. A great number of small construction companies and individual masons build and disseminate masoned fixed-dome plants of the Deenbandhu type. These plants are normally cheaper than the pre-fabricated models from *Shivsadan*, which means the masoned plants are more interesting for less financially sound farmers.

The type of household plants in demand, also with *Shivsadan*, shows a strong tendency towards smaller fixed-dome models. Although a completely different type of plant is disseminated here, Maharashtra also shows that fixed-dome plants (reliable performance) correspond most to the requirements of the target group of smallholders and medium-scale farmers.

The advantages and disadvantages of locally masoned Deenbandhu and pre-fabricated Krishna plants can be stated as follows:

**Deenbandhu plant: low capital investment, high flexibility in building and installation, building material is available locally but extensive quality assurance measures necessary by well trained craftsmen.**

**Krishna plant: easy to examine and thus a good standard of quality but high capital investment and increasing transport costs for greater distances. Additionally, large numbers are essential for economical production.**

## **Prices for a biogas plant**

If the price for a Krishna biogas plant with a digester volume of 6 m<sup>3</sup> is compared to the cost of a masoned Deenbandhu fixed-dome plant of the same size, as disseminated in Orissa by *Gram Vikas*, it can be seen that the total costs of the Krishna plants exceed those of the masoned fixed-dome plant by about Rs 1,000 (approx. DM 66). The difference in pure material costs is negligible; the labour costs for the pre-fabricated plant are lower by about half. In each case the costs for the transport of the pre-fabricated plant which increase with the distance between the factory and building site, must be added (for the comparison shown a minimum distance from the factory was assumed).

## **Geography, population and agriculture in Sangli (India)**

### **Geography and population**

Maharashtra, with 307,762 km<sup>2</sup> and a population in the region of 78 million, is the third largest federal state in India. Located on the western side of the continent, the coastline to Arabian Sea forms its western border. To the north and northwest Maharashtra borders on the federal states of Gujarat and Madhya Pradesh, to the southwest lie Andhra Pradesh and Karnataka, and to the south Maharashtra borders on Goa. The region shows a variety of characteristics: to the west there are the Konkan lowlands, a narrow strip along the coast which is marked by numerous small hills. Most of the region is dissected by the Western Ghats running from north to south over a distance of 640 km whose mountains reach heights of up to 1,340 m. These continue to the east as the Deccan Plateau which is a plain dissected by fertile river valleys which rise in the Western Ghats and run eastwards crossing

the Indian subcontinent to flow into the sea in the Bay of Bengal. The main project area, comprising the districts of Sangli and Kolhapur, are marked by this type of countryside: whilst Kolhapur lies in the mountainous area of the Ghats, the district of Sangli is located in the fertile lowlands of the Krishna and Sina rivers.

The climate is tropical with a mean minimum temperature of 19°C in January and maximum day temperatures of around 38°C in May. The monsoon brings the region a marked rainy period between June and October with an annual precipitation of around 2,000 mm on the coast and in the East of Maharashtra. Particularly the Ghats and neighbouring regions suffer from distinct periods of drought. There are four seasons: between March and May it is hot and dry, from June to September it is hot and wet, from October to November it is warm and humid and from December to February it is cool and dry.

Maharashtra in the Central Indian "Tribal Belt" is the home of countless peoples and ethnic groups who in some case have immigrated from other areas. About one third of the population belongs to varying indigenous tribes although the proportion fluctuates from district to district; in the extreme east of the country there are around 60% Adivasis.

Although Maharashtra is one of the most modern states in the country about 30% in urban centres and 40% in the country live below the poverty line.

## **Economy and agriculture**

Bombay, the capital of Maharashtra is at the same time India's most modern and most bustling city. About half of the foreign trade of India is handled through the city harbour. The city is the most important centre in the country for the processing industry: numerous production plants for textiles, vehicles, the pharmaceutical and petrochemical industry have settled in and around Bombay; the city is also an important centre of trade for the country.

Agricultural production is thus more intensive and generally better organised here than in other federal states, it is more developed and shows higher productivity. Despite intensive industrialisation, agriculture remains the most important source of income for two thirds of the population in this region. The main crops which are cultivated are rice, millet, sorghum, wheat, peanuts. Cash crops like cotton, sugar cane, grapes, tobacco and oranges are regionally important.

Ownership of land is unequally distributed: 8% of the rural households have about 40% of agricultural land. The majority of farms - 58% of all households - have less than 2 hectares of cropland; their share in the total area of agricultural land amounts to 14%. In the two districts with the highest number of biogas customers the majority consists of smallholders. About 50% of farmers own less than 1 hectare of land, 30% own 1 - 2 hectares and 20% have more than 2 hectares. In the project area the average area owned by biogas customers amounts to 3 acres (1.2 hectares). Their most important products are sugar cane, sorghum and wheat.

The districts of Sangli and Kolhapur in the south of the state where the Shivsadan biogas programme surveyed is located, continue to be extensively agricultural areas. The emphasis here is on the sugar industry and on the cooperative movement of Maharashtra. The Cooperative Farmers' Association has around 32,000 farmers as members. These and another 10,000 non-members from a total of 151 villages in the two districts cultivate sugar cane over a total cropland area of 40,000 acres (approx. 16,200 hectares). Every year around 1 million tonnes of sugar cane are delivered to the factory at Sangli. The Sangli Sugar Mill belongs to the cooperative and is the third largest sugar mill in India. The mill, employing approx. 2,500 workers and salaried staff, generates approx. 850 million Rs (approx. 50 million DM) annually. Apart from sugar, alcohol, acetic acid and animal feedstuffs are also produced. The cooperative not only provides an income for the 2,500 employees, the 32,000 members and the 10,000 farmers who are non-members but also for around 25,000 seasonal workers. Biogas technology is also promoted by the cooperative; a subsidy of RS 500 for building a plant is paid to members on application. Also bank guarantees allow access to credits for building biogas plants.



## **Environment**

A negative result of the intensive irrigation system is the salinisation of the soils which leads to continuing infertility of the areas concerned. One third of the agricultural land around the district capital of Sangli has become useless due to salinisation. This intensive irrigation has also resulted in a reduction in the groundwater level which falls to more than 100 m below the surface only a few kilometres away from watercourses.

In addition, the absolutely insufficient or non-existent disposal of (agro-)industrial wastewater is leading to problems; in Sangli district the direct inflow into irrigation canals and the Krishna river of 700 m<sup>3</sup> of wastewater from the sugar mill every day is a permanent problem.

# Biogas technology in the Ivory Coast (region of Korhogo)

## History

The biogas project began at the slaughterhouse in Ferkessedougou. For this, 2 large balloon plants were developed and constructed. The gas from these was used to produce electricity for the slaughterhouse in a generator. In 1982, the first six household plants with **balloon-type** gas-holders were built for the cattle herdsman and their families in the slaughterhouse pen. The objective of this measure was mainly to save on wood as a fuel. In the course of further dissemination it turned out that light produced by biogas played a great role in the demand for small biogas plants. For this reason, gas was promoted as providing light gas for cooking during the subsequent programme.

## Problems

By March 1991, a total of 80 family biogas plants had been built. This number includes all plants, as well as the first demonstration plants and those which have been put out of operation as well as those still operating. In 1991 there were still 10 of the 80 plants in operation. Of the 70 plants out of operation, 7 could be repaired, rehabilitation for 24 is likely, the rest must be written off. The following main causes for taking the plants out of operation were determined:

### 1) Technical Defects:

After a certain time, the foil becomes brittle and holes appear which have occurred due to damage by animals, children or other effects. The wooden frame to which the foil is attached quickly becomes weather-worn and is eaten by termites. The stoves produced from iron sheets by craftsmen rust quickly due to the high sulphur content and become blocked or completely break down. The flexible gas pipes become porous and leak because of the effect of sunshine.

### 2) Social Causes:

A lot of biogas plants were individual demonstration plants which were not really wanted by the users, but were more tolerated. Traditional sources of energy continued to receive preference. In polygamous households clear lines of responsibility were missing. The chief of the household traditionally does not get involved in disputes of the wives, and also in this case, had no direct right to issue instructions to the children. This is particularly the case in non-Islamic families where each wife cooks every day for her own children and in turn for the husband. Each wife's household should then be connected to the biogas plant, and service and daily management would have to be carried out by the husband (which would mean a completely new division of labour), or by the wives in turn. Apart from this there is also a conflict of interests between the source of energy for cooking wished for by the wives and lighting, which is the responsibility of the man.

In the demonstration phase when a large number of plants were built in many different places, there was a lack of liaison staff. Their own input at first was under 10%, later it rose to around 20%. After German participation ended, the biogas programme was integrated into the structures of the SODEPRA and put in the charge of the livestock extension officers. In line with structures of hierarchy, information flowed through 3 or 4 levels on the way from user to the biogas service. Furthermore, competence for the selection of sites was no longer with trained biogas staff, but with the livestock extension officers who did not have the necessary detailed knowledge to guarantee selection of an optimum site. Intensive training of the agricultural extension officers like, e.g. in Thailand, by the *Biogas Dissemination Programme* did not take place.

## **Slurry**

The slurry is never used in a liquid state. When needed, the dried slurry is scratched from the ground and taken to the fields. This is never seen as an additional asset and can also not be plausibly imparted to the farmers. Even a possible reduction of weed seeds in the fertiliser is unrealistic with this method of utilisation. To make biogas technology attractive and economically feasible there will have to be far more extensive measures towards restructuring within farms which e.g. introduce controlled composting of the slurry.

## **Geography, population and agriculture in the Ivory Coast (region of Korhogo)**

### **Geography**

The Ivory Coast has an area of 322,000 km<sup>2</sup> and a population of 12 million. In 1990 the GNP amounted to around 750 US\$ per capita which means that the Ivory Coast belongs to the lower category of countries with average income. The project area comprises the region of Korhogo in the north of the country and shows all the features of a country with a low income. It is a bush savanna region with linear forests seaming watercourses. It comprises the so-called "zone dense" and the "zone transitaire".

The "zone dense" extends to the south and to the southeast of Korhogo. The area is relatively densely populated and has experienced increasing deforestation since the end of the 19th century as a result of the clearing of areas for arable farming and to obtain wood. The linear forests and trees have been extensively replaced by a grass savanna loosely interspersed with fruit and other useful trees (baobab, néré, karité, mango, cashew etc.) distributed over the agriculturally used and over unused land. The relatively intensive agriculture with only short fallow periods has resulted in increasing lateritic property of the soil.

The "zone transitaire" extends along the border to the "zone dense" and is a transition between intensively used land and the scrub and tree savanna. It extends over the north and northeast of the region.

The climate is tropical with a distinct rainy season. The average precipitation amounts to about 1,500 mm in Korhogo. The annual precipitation fluctuated in the period 1975 to 1984 by between 835 and 1557 mm. The rainy season from April to October is the time of intensive agricultural activity. There is an arid period of 3 months with dry and cool winds from the north. During this period there are great differences in day/night temperatures.

### **Population**

The whole of the north is marked by cultural and lingual homogeneity of the Sénoufo to a great extent. In addition to this, the project area is inhabited by the Malinké, generally called Dioula, who originally immigrated from the north and who are Moslems (the Sénoufo mostly belong to their traditional natural religion). The Dioula are mainly concerned with trading, the processing of foodstuffs and itinerant trading. The third ethnic group is the Peulh, who are nomadic herdsmen and came here mainly after the great drought in 1974 from the Sahel. They live in mixed settlements with the established arable farmers and are still partly transhumant. On the whole, there are great differences in the density of the settlements which reaches 80 inhabitants per km<sup>2</sup> in the "zone dense".

### **Agriculture**

The traditional system practised by the Sénoufo is arable farming which secures their subsistence. After having concentrated exclusively on the provision of foodstuffs, nowadays more and more crops which can be marketed and turned into monetary income are being cultivated (e.g. cotton). Livestock farming is more understood as a way of accumulating surpluses from arable farming and constitutes the traditional bank, since when this is necessary (burials, weddings, starting school etc.) it can be quickly accessed.

The Peulh mainly base their production on livestock and animal husbandry. Arable farming is only of a subordinate role for them. The rapid growth of the Peulh herds has led to increased damage to the crops of the Sénoufo and to tension related to this. For this reason livestock husbandry is considered by many of the Sénoufo to be a destabilising factor for arable farming.

# **Biogas technology in Jamaica**

## **Biogas utilization**

Since the early 1980s agricultural biodigesters have been known and introduced at a very slow pace to Jamaica with the Scientific Research Council (SCR) being the major promoter as a reply to the energy crisis in the 1970s. Decentralised energy production was the crucial topic rather than waste management and environmental issues involved. The slow-down of the energy debate has further reduced application and assistance to the technology.

With an overall of 120 units existing in Jamaica a national programme was started in 1993 and based on a project progress control and finding mission solely to concentrate on dissemination of the existing small scale agricultural biogas digesters.

## **Potential for biogas production**

The potential for biogas production has been assessed from a different perspective. On the whole it is huge, in particular for agro-industrial wastewater in Jamaica.

As biogas is commonly and frequently associated with animal residue handling at farms, there seems to be difficulties of promoting this environmentally sound approach towards wastewater treatment under the term biogas.

The total biogas production potential in Jamaica is over 20 million m<sup>3</sup> of gas per year. The expected energy savings for aerobic wastewater treatment are far over 100 Gwh per year.

# **Geography, population and agriculture in Jamaica**

## **Geography**

Jamaica is the third largest island in the Caribbean, measuring 233 km in length and 80 km in width. It is situated 145 km South of Cuba. A mountain range spans its length. Over half of the island is more than 300 m above sea level and the highest peak lies in the Blue Mountains at a height of 2256 m.

## **Population**

Jamaica has a total population of 2.5 million (1992) and an area of 10,830 km<sup>2</sup>. One third of inhabitants live in the capital Kingston. Nearly 50 percent of the people live in the rural area; 30 percent of the working population is employed in the agricultural sector.

## **Economy and agriculture**

Tourism is the main source of foreign currency, followed by bauxite and agriculture. However agriculture contributes only 9 % towards Gross Domestic Product (GDP). In Jamaica there is a rapidly expanding sector of entrepreneurs and small investors. Jamaica has a booming stock market.

In 1993 real GDP grew marginally per 1.2 percent. The sluggish growth out-turn reflected generally slower growth in most of the goods-producing and services sectors as well as contraction in the heavily-weighted 'Manufacture' sector and 'Construction and Installation'. 'Miscellaneous Services' which includes tourism-related activities and 'Transport, Storage and Communication' were the only two sectors to register faster growth in 1993. 'Agriculture, Forestry and Fishing' was the only goods-producing sector to perform creditably growing by 8.8 percent.

Traditional agricultural export crops are sugar-cane, bananas, citrus, cocoa, coconut, coffee and pimento. Additionally tubers, vegetables, fruits and ornamental horticultures are exported. Cereals, meat and fish products account for the bulk of imports.

# Biogas technology on Java (province of Central Java)

## History

BORDA (*Bremen Overseas Research and Development Association*), a German consultancy, has been working since 1989 with the non-governmental organisation LPTP (*Lembaga Pengembangan Teknologi Pedesan = Institute for Rural Technology Development*) on an *Integrated Rural Development Project* (IRDP) sponsored by the *Federal Ministry for Economic Cooperation of Germany*. The LPTP was founded by very involved students in 1979 who attach great importance to participation by the target group in each case. The central field of activity was in the development and dissemination of appropriate technologies. Biogas has only been part of the LPTP programme since BORDA entered the cooperation.

At the beginning of the eighties a number of biogas plants were installed in the project area through the agricultural extension service of the regional administration. None of the plants ever supplied energy for the operators because of serious defects in the plant system. Consequently, project staff were faced with scepticism and a lack of interest on the part of members of regional administration. LPTP, in the meantime, has shown that technically perfect biogas plants can be built and are useful for farmers. The former situation has changed drastically on the basis of this, so that LPTP, in cooperation with the regional administration, was able to arrange a national conference on biogas with over 100 participants in autumn 1992.

## Types of plant

After a survey of the project area, carried out by BORDA and the LPTP which established all data relevant to biogas, had shown the region to be basically suitable for biogas dissemination, the IRDP employed an engineer for this sector. In the late autumn of 1990 a BORDA engineer supervised the construction of the first three **fixed-dome plants**. In autumn 1992 there were 58 biogas plants, and by December a further 27 had been built including a large-scale plant of 93 m<sup>3</sup> digester volume for a dry meat producer. Otherwise, standard types with a volume of digester of 6, 9, 13 and 18 m<sup>3</sup> are offered. The large number of new plants can be attributed to the dissemination area being extended to include a community between Cepogo and Boyolali.

So far there has only been one case of gas leakage on a plant and this was immediately repaired by the project staff. Good quality and high gas yields (0.275 m<sup>3</sup>/m<sup>3</sup> volume of digester per day) combined with an exemplary fertiliser advisory service mean that not only the biogas department, but also IRDP as a whole, has a good reputation in the region.

## The CAMARTEC type

The type of plant selected and adapted to Javanese conditions was the fixed-dome plant with a "**weak-ring**" developed further by **CAMARTEC** of Tanzania. As stabling and the use of organic fertilisers was already known, the principle propagated by CAMARTEC, the "biogas unit", could be consistently adhered to. The Javanese version differs from the Tanzanian one in the following points:

- 12 cm wall thickness in the semi-spherical dome; as the bricks are only 4 - 5 cm thick it is difficult to lay them in one-quarter brick thickness.
- conical floor board; in addition to giving better static properties, the bowl-like floor serves as a water bath for the bricks.
- reinforced "strong-ring" to provide safety against the frequent, light earthquakes.

Since 1992 the "weak-ring" has been omitted as it is assumed that the change in cross-section below the "strong-ring" automatically functions as a predetermined breaking point.

When the cattle were fed on king-grass, there were frequently problems with scum in the plant. The high position of the pipe to the compensation chamber presumably made this problem worse. Since 1992, the digester and compensation chamber have been connected

by a shaft running from the bottom of the digester up to under the "strong-ring". In some cases, older plants were converted by means of a by-pass shaft. Since then the problem seems to have been solved even if the scum itself cannot be avoided.

The interior plastering was carried out with the agent "Tricosal" in three layers of plaster, three intermediate brushing coats and a final coat of finishing plaster. The gas pipes consist of 1/2" PVC pipes but where these are longer than 50 m, 3/4" pipes are used. The water trap consists of a short U-pipe with a gas-tight plug which can be opened when necessary.

## **Geography, population and agriculture on Java (province of Central Java)**

### **Geography**

The project area consists of the rural districts of Cepogo, Selo and Ampel in the region of Boyolali in the province of Central Java. It lies on the eastern slopes of the Merbabu (3142 m) and Merapi (2911 m) volcanos of which the latter is still active, and extends over the pass at Selo (1500 m above sea-level) to the villages of Tlogolele and Klakah. The biogas project area of about 100 km<sup>2</sup> is densely populated by 70,000 inhabitants carrying out intensive agriculture (the total project area is approximately twice as big). The main crops are tobacco, vegetables and cloves as cash crops, cassava for home consumption and grass as fodder for stabled cattle. Bananas and coffee are also common; crops are grown corresponding to the altitude. Rice, the staple food, is bought or obtained from fields in the plains.

The villages consisting of several hamlets, stretch along the roads which are asphalted in some cases and which follow deep valleys dissecting the countryside. The steep slopes are at risk from erosion. The climate, corresponding to its position on 7° south latitude, is tropical but at altitudes of between 500 and 1,500 m very pleasant (10 - 30 °C). Dry and rainy seasons are not so extreme which means that agriculture can extend over the whole year and provide up to three harvests on the fertile volcanic soils. Each farm has between 0.5 and 2 hectares and 89% of farmers have less than 1 hectare of land. With almost 2 cows per household, this is the peak region throughout Indonesia. The annual income of the farmer amounts to between 130,000 and 210,000 IRP (64 - 103 US\$ p.a.).

### **Population**

The population is predominantly Javanese, mostly belonging to the Muslim faith. Christians and members of traditional religions only form a minority. Social differences are less severe due to traditional patronage of richer farmers.

The greatest problem evident in Java is the dense population (813 inhabitants per km<sup>2</sup> with a growth rate of 1.8%). The state is attempting to motivate the population with migration programmes to move to other, less densely populated islands (Kalimantan, Sulawesi, Sumatra and other small islands).

### **Economy and agriculture**

Goods needed on a daily basis are mainly produced in Indonesia although the electronics, machinery and vehicle markets are still dominated by foreign goods. The project region itself is only slowly beginning with industrialisation from the plain. Agriculture will continue to constitute the main economic factor for a long time. Livestock husbandry and verification of agriculture are being strongly supported by promotion programmes and propaganda. An insidious tobacco disease in the soil and the fall of prices due to market losses necessitates new orientation of the farmers towards other cash crops or towards the production of meat and dairy goods.

On principle, farmers have access to agricultural investment credits and use their land as security for these. The price of rice is guaranteed for the farmers, there are fixed consumer prices for milk in the towns. Stabling and the use of organic fertiliser is promoted publicly and

is traditionally common. So far, chemical fertilisers have been subsidised but this is slowly being abolished.



# Biogas technology in Kenya

## History

There were already first attempts to use biogas technology to gain energy from coffee pulp in Kenya in the mid-fifties. In the following 25 years, more than 100 plants of varying types were sold mainly to large-scale farmers by a private entrepreneur. After the energy crisis, interest in this technology boomed. A number of Indian **floating-drum plants** and Chinese **fixed-dome plants** were installed particularly for public institutes, like schools and other education centres by private organisations often with foreign sponsors. However, since not only did the technical quality leave much to be desired, but also the social and economic conditions were not taken into consideration during implementation of the plants, the plants themselves soon were no longer filled and/or were out of operation due to technical problems. In the context of the *Special Energy Programme (SEP)* Kenya in 1983/4 several craftsmen were trained in the construction of biogas plants by **GTZ** short-term experts and these went on to build around 40 biogas plants in the Mount Meru region. However it was soon evident that training craftsmen in the construction of plants alone was not sufficient to guarantee permanent function of the plants or the extension of dissemination into other regions. Shortcomings evident were no kind of quality assurance, no advice for the customer on how to operate the biogas plant and no dissemination strategy. To alleviate this, a long-term expert was employed to provide advice in Kenya in 1985. Around 250 floating-drum plants were installed in various regions by the SEP in cooperation with the *Ministry for Energy* by 1988.

## Financial supports

The budget of the Biogas Section for 1992 amounts to approx. K£ 25,000. This corresponds to about US\$ 2,500 per year for training, infrastructure and public relations work and about K£ 200,000 (approx. US \$ 15,500) for the wages of 10 members of staff who are not only involved in biogas work. Approx. KSh. 50,000 (US \$ 1,500) for training, infrastructure, monitoring and public relations work were made available for 1992 from SEP funds. These funds will however not be provided from 1993 onwards.

## Function of the plants

Of the 49 biogas plant owners, around 1/4 (13) stated that plants had functioned without any problem since they had been built. 8 of these plants are no older than 2 years, the oldest has been operating for 7 years. 9 plants built between 1984 and 1988 are no longer in operation. The reasons for this are stated as being:

- is no longer filled: 5
- inferior gas production: 1
- gas leaks and pipes defect: 2
- inlet pipe broken: 1

# Geography, population and agriculture in Kenya

## Geography

Kenya, on the eastern coast of Africa, is dissected across the centre by the equator. The majority of the population (85%) lives in the southwestern part of Kenya which comprises of a rising elevated plateau with Mount Kenya (over 5,000 m) falling to Lake Victoria in the west. Along the coast there is a mean temperature of 27°C but in the interior of the country it is cooler. April to June and October to December are the rainy seasons and can come with annual precipitation of 1,250 mm in the uplands and around 1,000 mm on the coast. The lowest precipitation occurs in the north with a maximum of 600 mm and the highest is in the west, around Lake Victoria with about 1,780 annually.

## **Population**

According to official estimations in 1989 there are approximately 24.5 million inhabitants over an area of 571,416 km<sup>2</sup> (approx. 42 inhabitants/km<sup>2</sup>). 22% of the population lives in towns and the tendency is increasing. The annual growth rate of the population in Kenya is about 3.5% (1990). 98.5% of the population is African of which most belong to the Bantu peoples like the Kikuyu with 21% and the Luo with 13%, but also to Nomad peoples e.g. the Massai. The remaining 1.5% comprises Asian, Arab and European nationalities.

## **Economy and agriculture**

The strengths of the Kenyan economy lie in the production and processing of agricultural and pastoral products. The contribution of agricultural, forestry and fisheries to the GDP in 1988 was around 32%. The industrial sector contributed 19% of which 13% was contributed by the processing industry. The services sector contributed around 35% to the GDP. The central problems in the Kenyan economy are high population growth and an unemployment rate of around 40%. An economic upswing which started in 1986 slowed down in 1989/90 due to lower prices on the world market for coffee and tea and the effects of the crisis in the Gulf which cost the country around 125 million US\$.

Kenya has no mineral resources worth mentioning and depends on agriculture to a great extent. Although wide expanses of Kenya, particularly in the north-east, north-west and in the south-east are arid and infertile and can thus only be used for agriculture sporadically, 3/4 of the population live from agriculture. Small farms are predominant which are normally attended to by women alone (27%) or by women in the absence of their husbands (47%). Subsistence farming is combined with market-oriented production. The staple food is maize and is subsidised by the government. Other subsistence crops are manioc, potatoes and millet. Crops grown for the market are mainly coffee, tea, sisal, pyrethrum, wheat, sugar, pineapple and cotton. Coffee and tea are the most significant export products with 25.6% and 19.5% (1988) respectively. The total number of cattle in Kenya is estimated to be 10 million. In recent years, agriculture has experienced a decline in the production of the most important agricultural products.

## **Energy**

Power generated for the country by hydro-electric and thermal power stations is below demand. In 1988, energy amounted to about 14% of total imports. The connecting of rural regions to the electricity supply is being subsidised. Electricity however, accounts for only 3.3% of the total consumption of energy in the country. About 83% of household energy is met by firewood and charcoal.

## **Environment**

According to the report issued by the World Bank in 1992, Kenya like other countries south of the Sahara, is facing the effects of environmental damage on the economy and on health. Apart from increasing air pollution in the cities, and the development of smoke in households during the use of firewood which is a hazard to health, what is centrally stated is the effect on agricultural production. The rapid growth in the population has led to forest resources and the fertility of the soil becoming exhausted and thus to a fall in agricultural production in densely populated areas. According to the Ministry for the Environment, the development and dissemination of technologies for the utilisation of natural resources has been given top priority. Previous alternatives to the use of firewood and charcoal are considered to be too expensive to have a significant effect on environmental damage occurring from the use of firewood.

# Biogas technology in Morocco (region of Souss-Massa)

## History

The first activities concerned with biogas date back to 1983. Within an agreement between the CDER (*Centre de Développement des Energies Renouvelables*) and the ORMVA (*Office régionale de mise en Valeur Agricole*) Haouz, three experts took part in a 20-day training course for biogas technology in China. During the course of various programmes between 1983 and 1990, 60 biogas plants alone of the Chinese **fixed-dome plant type** were built by ORMVA Haouz. In one cooperation with UNICEF lasting from 1984 - 91 (which was to improve sanitary conditions in rural areas) the Ministry of Agriculture (with the intention of protecting the forests and improving the general living conditions of farmer families) provided approx. 600,000 Dh for biogas technology. The aim of these efforts was to embed biogas technology in all ORMVAs and *Division Provinciale de l'Agriculture* (DPA) by means of intensive training programmes and the establishing of a national dissemination structure. At the same time a *Centre de Formation* was set up at the *Ecole Nationale de l'Agriculture*. In 15-day courses mostly carried out in Marrakesh, a total of 70 masons, 115 technicians and 61 agricultural extension officers were familiarised with biogas technology (Information ORMVA-Haouz). According to records held by the CDER, in 1992 there were 255 biogas plants in Morocco mostly with digester volumes of 10 m<sup>3</sup>. In addition, other individual biogas activities were carried out within the scope of various agreements, for example the 150 m<sup>3</sup> **batch plant** built by CDER for research purposes. In 1989-90 a Chinese team constructed a 150 m<sup>3</sup> community plant in Marrakesh.

## Problems

The results of these efforts are disillusioning. According to an investigation carried out by CDER, 63 of the 139 plants (Chinese models) were completely at a standstill in 1990, 37 showed weak or just satisfactory production and only 39 were classified as "good". The ORMVA Haouz stated 40 of the 80 plants they had built to be completely incapable of function. A systematic analysis of the causes taking a differentiation between technical reliability and problems originating in social acceptance into consideration, is not yet available.

## Special Energy Programme of the GTZ

The dissemination of biogas technology in the Souss-Massa region is a sub-project of the **GTZ's Special Energy Programme Morocco** which has been carried out since 1988. The purpose of the *Special Energy Programme Morocco* at that time was to improve the energy situation in rural areas - threatened by ecological degradation - by modifying and disseminating "renewable sources of energy". The focal point of project planning was to reinforce national project executing organisations for renewable energies, particularly the *Centre de Développement des Energies Renouvelables* (CDER).

In the field of biogas, the project concept sees the activities in Souss-Massa to have a pilot function for other regions of Morocco. Over the medium term the various regional ORMVAs and the *Divisions Provinciale d'Agriculture* (DPA) which are not actively involved in irrigated areas are to carry out concrete implementation and dissemination. The CDER is then to take over the role of the institution involved in research, development and advisory services and that of the actual national source of know-how. A *Biogas Committee* set up in spring 1992 on which decision-makers from various institutions affected by biogas dissemination are represented, is over the medium term, to constitute a legal link between the political decision-making levels and the corporations commissioned with biogas dissemination and is to be equipped with the relevant competence to define directives. The rehabilitation of 3 fixed-dome plants, the construction of three 12 m<sup>3</sup> plants, five 20 m<sup>3</sup> plants and two 85 m<sup>3</sup> plants (mainly to drive motors) have demonstrated the technical efficiency biogas plants can provide with qualified construction planning and execution. It is the objective to integrate biogas technology into the structure of the ORMVA/Souss-Massa so that in future it will be offered to farmers as a normal (i.e. also highly subsidised) service of the ORMVA. It is

intended to have biogas plants included in the credit framework for agricultural inputs of the agricultural bank *Caisse Nationale de Crédit Agricole*.

## **Potential for biogas**

The potential for biogas in the Souss-Massa region defined by the *Biogas Office* according to biomass available is approx. 20,000 biogas plants. This quite enormous potential is a projection of the data available on livestock numbers at the ORMVA, which would ultimately result in 7,146 12 m<sup>3</sup> plants; 4,422 20 m<sup>3</sup> plants; 4,584 30 m<sup>3</sup> plants; 2,346 50 m<sup>3</sup> plants and 1,416 85 m<sup>3</sup> plants. The actual potential however is likely to be far lower although many of these farms have a relatively strong background of capital. Particularly larger farms have high-performance, pure-bred (3,000 farms in 1990) or cross-bred cattle.

## **Geography, population and agriculture in Morocco (region of Souss-Massa)**

### **Geography and population**

The Project region of Souss-Massa lies in the south of Morocco and consists of the administrative regions of the Agadir province and Taroudant. Bordered in the west by the Atlantic, in the east by the Atlas mountains from north to south, i.e. the Anti Atlas, its total area amounts to approx. 12,000 km<sup>2</sup>. Of this, the Souss-Massa plain takes up approx. 575,000 hectares. The total population amounted to 1,037,400 in 1982, the Arabian population making out around 20% and the Berbers 80% (Taroudant 40% and 60%) in Massa.

The climate on the Souss-Massa plain is semi-arid and influenced by three factors: the opening to the Atlantic Ocean, the chains of mountains converging to the east and the desert zone. Protected by the massif, a moderating influence of the Atlantic Ocean can be observed up to 30 km into the interior of the plain and thus allows the cultivation of early crops. In Taroudant annual precipitation amounts to 228 mm, January having the highest precipitation with 144 mm. This low degree of precipitation mostly concentrated into only a few days proves to be very limiting to agriculture. The mean temperatures in Taroudant amount to 13.6°C in January and 27.1°C in July. Atmospheric humidity is 1,407 mm in Taroudant.

### **Agriculture and economy**

Agriculture is of major importance to the Moroccan economy and employs 40% of the working population. Its contribution to the GNP amounts to between 15% and 20% depending on the harvest, and to approx. 25% to exports. The tertiary sector, extensively marked by trade, is with 35% a major contributor to employment. The differentiated producing sector contributed 18% to the GNP in 1989. Phosphate and its industrial derivatives form the most important source of foreign currency followed by agricultural products (mainly citrus fruits). Considerable fluctuations in the GNP are chiefly a result of agricultural yields being extensively influenced by fluctuations in precipitation. Agriculture is mainly pursued along the coastline although the Central Atlas also shows significant agricultural production.

Agriculture in the project region of Souss-Massa is significant in supplying the domestic markets and for export and, in line with this significance, was highly subsidised. In 1988 it produced 413,000 t citrus fruits (50% for export) and 381,000 t vegetables which corresponds to 30% and 17% of national production. (In addition, a production of 156,000 t cereals and 61 million litres of milk). The fact that more than half of the 228,000 hectares of intensively cultivated arable land is irrigated shows the success of the irrigation policy pursued by the ORMVA Souss-Massa in the so-called "Golden Triangle" since 1978. In 1990 the number of cattle was estimated to be 122,000.

## **Energy and environment**

The region is confronted by a rapid decline in the Argania forests which are important for the climate of the region. This shows that the most important traditional source of energy in Morocco (particularly in rural areas) remains to be wood. More than 80% of the primary national energy production is gained from wood. An efficient control of wood felling by the authorities despite legal regulations does not exist. The substitution of wood as a source of energy is formulated politically and supported by the subsidy of bottled gas, yet the protection of the forests has not yet found any efficient concept. As evident in the region of Souss-Massa for example, the technical competence of the organisations responsible is directed more to extensive conservation of the resource water.

# Biogas technology in Nepal

## History

The beginning of biogas activities in Nepal was a programme carried out by the *United Missions to Nepal* within the context of the Agricultural Year 1974/1975 whose objective was to introduce biogas plants similar to in India. The *Agricultural Development Bank of Nepal* (ADB/N) assisted in financing the plants by providing a special credit framework. The *Gobar Gas Tatha Krishi Yantra Vikas (P.) Ltd. (Biogas and Agricultural Equipment Development (Pvt) Ltd.)*, normally called *Gobar Gas Company* (GGC), was founded in 1977 by the ADB/N, the *United Missions to Nepal* (UMN) and the *Nepal Fuel Corporation* (today: *Timber Corporation Nepal* - TCN).

During the history of the company various foreign sources have been involved in promoting biogas dissemination through the GGC. Since 1988 the *Netherlands Development Organisation* (SNV Nepal), has been working with the GGC with the involvement of two Dutch experts in the "Research Unit" and "Workshop" divisions. This cooperation was expanded into a financially more extensive *Biogas Support Programme* at the beginning of 1992.

## GGC biogas programme

The GGC biogas programme is the only supra-regional dissemination programme in Nepal. The building of plants is organised by two regional offices in western (Butwal) and eastern Terai (Biratnagar) and by 11 district offices belonging to these as well the dissemination office in Kathmandu belonging to the main office. Each of the dissemination offices of the company sells, installs, repairs and services biogas plants. The research department is responsible for the development of technical solutions and dissemination structures where possible cost reduction, improvement of customer service and the solution of specific problems in daily use are concerned.

In 1992, there were approximately 6,000 biogas plants in Nepal. Of these, about 4,500 were installed by the *Gobar Gas Company* in various parts of the country. About 70% of biogas plants are located in Terai. Not counting the biogas plants in upland valleys, only approximately 13% are in mountainous regions. This is explained by difficult access conditions to farms in the mountains which makes the transport of building material very expensive so that farmers in mountainous regions can hardly afford biogas plants.

## Types of plant

So far, mainly two types of plant have been built and disseminated in Nepal. These are the **floating-drum plant** based on the Indian type (with an overflow at the top rim of the cylindrical digester instead of an outlet pipe) and **fixed-dome plants** with a flat floor, cylindrical digester and a dome made of concrete. The market-oriented procedure soon led (and earlier than in India) to fixed-dome plants becoming the standard model: since 1980 fixed-dome plants have primarily been disseminated mainly for reasons of cost. These are offered in digester sizes of between 4 m<sup>3</sup> and 50 m<sup>3</sup>.

The Nepali fixed-dome plant is a development peculiar to Nepal which has been modified in various ways over the years. The construction reflects the particular dissemination conditions of the country:

- The form of the digester, the compensation chamber and inlet are simple geometrical figures which, if bricks are not available on site or are difficult to transport there, can be built from natural stones.
- The dome storing gas is plastered or moulded out of concrete on a clay mould. In this case, the building material necessary (normally only concrete since gravel and sand are often available locally) can be brought to the site packed in sacks.

## **Construction of a fixed-dome plant in Nepal**

Building a fixed-dome plant - with regard to the work invested by the farmer - involves a great amount of work. After a cylindrical pit has been excavated to the prescribed depth, the floor slab is laid and the cylindrical wall of the digester is erected on it. In cases where the ground is very firm or rocky, a masoned digester wall is dispensed with; the wall is then only plastered from the inside. The digester is subsequently filled with the excavated earth. At the top the inside form of the dome is shaped in clay using a template. Finally, the concrete is applied on a layer of sand with a trowel and smoothing board. After the dome has hardened, the earth is shovelled out through the large opening in the compensation chamber.

The majority of newly installed plants by far have a nominal digester volume of 10 m<sup>3</sup> which includes the total volume of the digester and gas storage tank but not the compensation chamber. According to the definition of average digester volume of fixed-dome plants, this corresponds to a digester volume of 7.8 m<sup>3</sup>. (With fixed-dome plants the level of liquid varies according to how much gas is in the dome. To determine an average value for digester volume half of the maximum gas storage volume plus permanently present digester volume is assumed - i.e. at the highest volume of gas and lowest level of liquid in the digester - according to the BORDA definition). The other sizes offered show no clear tendency as not only smaller 8 m<sup>3</sup> plants but also larger 15 m<sup>3</sup> plants were sold in almost the same numbers. The smallest plants with 4 m<sup>3</sup> digester volume were not ordered in 1991/92.

The plants are designed for a hydraulic retention time of 65 - 70 days. With a daily filling of 60 kg dung (from around 4 - 6 cattle) - in the climatic conditions of Terai - a gas yield of 2.4 m<sup>3</sup>/d is to be expected. This quantity provides sufficient energy for cooking for a household of 7 - 9 people. If a toilet is connected the expected gas yield rises by about 15%.

In Nepal the construction material is also the largest cost factor in a biogas plant. It amounts to between 71% (for digester volume = 20 m<sup>3</sup>) and 83% (digester volume = 4 m<sup>3</sup>) of the total costs according to the size of plant. The most expensive individual item is cement, followed by the gas pipes.

The GGC plants fulfil the same requirements on reliability of operation as fixed-dome plants in other countries which have been constructed in a different way. Their type of construction however, seems somewhat exotic (especially in Terai where bricks are the normal building material) in the face of existing experience throughout the world with masoned gas domes. Savings could be made in constructing the dome as, with masoned domes, the extra work involved in re-filling the excavated pit and re-digging is dispensed with.

Despite an unfavourably positioned gas outlet which is too low, the plants mostly operate without any trouble. The gas outlet in the dome is located - depending on the size of the plant - between 11 and 17 cm lower than the overflow at the compensation chamber and, for this reason, can become blocked with sludge if the gas is let out at the same time as the plant is being filled with dung. Problems are reported only during the colder months of the year when sludge is occasionally pressed into the gas pipes with the gas and blocks these.

## **Geography, population and agriculture in Nepal**

### **Geography**

Nepal lies on the southern flanks of the central Himalayas as an 835 km long and 90 to 230 km wide strip of land comprising an area of 147,181 km<sup>2</sup>. Within this small area, Nepal has differences in altitude of over 8,500 m like no other country on earth. From the border to India in the south the land rises from the humid-hot plains of the Terai with an altitude of around 100 m above sea level upwards towards the north. Over the foothills of the Churia Range and the Mahabharat Range with altitudes of up to 2,000 m, the country opens up into the broad upland valleys of the central country which lies at altitudes of between 1,000 and 2,000 m, has a temperate sub-tropical climate and provides settlement area for the majority of the population. Further north then come the mountainous regions of lower and the central Himalayas. In the central Himalayas or upper Himalayas where the country borders on Tibet,

with eight mountains of over 8,000 m, is also Sagarmatha, or Mt. Everest, which at 8848 m is the highest mountain on earth. Expressed in percentages, the Terai covers 17%, the central mountains 68% and the uplands 15% of the total area of land.

Like in India, the climate is dominated by the monsoons bringing rain from June to September from the south. During the rest of the year dry winds from Central Asia are predominant and prevent precipitation. The amount of precipitation depends on the altitude. Between 2,000 and 3,000 mm of rain fall on the central mountains; precipitation in the upland valleys amounts to 1,500 mm annually. Temperatures too show a similar variation: in the upland valleys the minimum temperature in December and January falls to freezing point at night in December and January with temperatures during the day of between 16° and 20°C. In the hills and the high Himalayas temperatures vary far more. Settlement reaches altitudes of up to 4,000 m where minimum temperatures of -10°C are reached. Biogas plants are operated up to altitudes of 1,500 m.

## **Population**

Nepal has a population of about 18 million. The calculated density of the population amounts to 115 inhabitants per km<sup>2</sup>, however, the area which can be settled is far smaller so that the true density amounts to around 440 inhabitants per km<sup>2</sup>. Population growth is 2.7% per year.

## **Agriculture and economy**

Agriculture and tourism are the main sources of income in the country. Agriculture contributes around two thirds to the GDP; income from tourism amounts to about 17%. The state budget is in deficit and is financed by means of funds from international development aid to approx. 40%. With an annual per capita income of approx. 300 DM, Nepal is one of the poorest countries in the world. These figures, however, considering the living situation of the majority of the population are not an adequate indicator of prosperity since most of the inhabitants in rural areas carry out subsistence farming. The inadequate infrastructure of the country is considered to be the main reason for the low productivity in agriculture.

Over 90% of the population in Nepal live from agriculture. Rice, sugar cane, maize, sorghum, oilseed, barley, wheat, tobacco and tea are the most important products. 80% of all exports are or are based on agricultural products. Agricultural production is not sufficient to provide adequate foodstuffs for the inhabitants due to the geographical and climatic conditions and the rapid growth rate of the population. The structure of Nepal's agriculture is mainly that of small-scale farms. The average size of farm is around 0.5 hectares in the "hills" (central mountains and lower Himalayas) and about 1.5 hectares in Terai. Animal production is not an inconsiderable factor in enhancing the arable crops, but meat production for religious reasons is limited to sheep and goats; cattle and water buffalo are mainly kept for dairy products and as draught animals. There are estimated to be around 12 million of the latter; stabling is widespread due to difficult terrain conditions. Cattle dung is sought after as a raw material for fuel and fertiliser.

## **Energy**

The total energy requirements of the country is estimated to be 252 million GJ annually. The largest proportion is used for consumption. The primary source of energy used for productive purposes in agriculture is still human and animal labour.

## **Environment**

Decades of ruthless exploitation of the forests in the Himalayas which are endangered by erosion as it is, have left behind massive, ecological imbalance. The increasing pressure of the population is affecting isolated parts of the country where organised timber thefts are diminishing the resources of local populations to a great extent. Subjected to uncontrolled felling and sparse re-forestation measures, the countryside is falling victim to erosion. Also the use of existing forests as pastures for cattle or for obtaining feedstuffs is causing great damage. Also the Terai, which was densely forested until well into the fifties, the claiming of land for cultivation has led to a situation equal to complete deforestation.



# Biogas technology in Tanzania

## History

The history of biogas dissemination in Tanzania dates back to 1975 when the *Small Industries Development Organisation* built 120 **floating-drum plants** up to 1984. In the Arusha region the *Arusha Appropriate Technology Project* constructed traditional Chinese **fixed-dome plants** and "floating-seven-drum digesters", their own development consisting of a gas holder made of 7 oil drums connected together. The objective of this project was to build biogas plants at the lowest investment costs possible. In 1982 the newly founded parastatal *Organisation Centre for Agricultural Mechanization and Rural Technology* (CAMARTEC) continued the dissemination of this technology in the Arusha area. About one year later Technical Cooperation between Tanzania and Federal Republic of Germany led to the introduction of the *Biogas Extension Service* (BES). CAMARTEC and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) were in charge of implementing this project and the latter seconded an interdisciplinary team (social scientist, mechanical engineer and agriculturist) to Tanzania. Only a few of the more than 100 biogas plants built were still in operation at this time.

In the initial years the BES disseminated biogas plants mainly in the so-called "Coffee and Banana Belt", the region around Arusha where particularly positive conditions promised a high dissemination density for biogas plants:

- a fertile region with high productivity and a dense population (192 inhabitants/km<sup>2</sup> cf. national average of 25/km<sup>2</sup>)
- smallholding structure, farm households own an average of 1.5 acres of land
- extensive animal husbandry for dairy production
- relatively well-off farmers as widespread additional income from other jobs

## Standardisation

Concentration on a project area which could be easily observed with good conditions led relatively early in project history to standardisation not only of the plant design, of administrative procedures, of guarantees (2 years) but also of user advice which in view of the high dissemination density could be carried out village for village. In 1984/85 household plants were offered with a digester volume of 8, 12 and 16 m<sup>3</sup>, in 1990 the programme comprised standardised plants of sizes with 12, 16, 30 and 50 m<sup>3</sup> for households and institutions as well as a toilet biogas plant for an institution.

## Technical development

A variety of technical development work was necessary to guarantee long-term performance of the plant. The fixed-dome plant initially disseminated by the BES proved to be non-reliable in practice. After 3 years of operation cracks allowing gas to leak out appeared on many plants with a digester volume of over 8 m<sup>3</sup>. The cause of this was seen to be in that the dome construction was not statically determined and cracking from the digester region up to the gas storage area could not be prevented. The solution to this problem was a pre-determined breaking point, the so-called "**weak ring**". Later a reinforcing ring, the "**strong ring**" made of concrete was added over this. This guaranteed that the gas storage area remained free of cracks. Another technical innovation which proved to be beneficial was the use of an additive in the cement for the gas-proof plaster. In the meantime the experience gained by CAMARTEC has been used successfully in many biogas dissemination programmes.

During cooperation work with a Kenyan organisation gas burners were developed which were reliable, easy to service and which corresponded to the cooking habits of the region. Supply problems and inferior performance of imported gas lamps led to an own model being developed and to the modification of petroleum pressure lamps for operation by gas. A kit developed for this purpose was exported to other GTZ projects. In other projects only the idea was taken up and this led to more simple solutions, e.g. in Java. The use of biogas for

large-scale consumers necessitated the development and distribution of a gas cooker for institutions which only works with primary air and thus burns stably.

The development work towards sustainable reliability and user friendliness resulted in extensive integration of biogas plants into the work routines of farmers. As a "biogas unit", a system of coordinated components was developed to include not only the plant but also integration into the farm system. This included livestock housing with a concrete floor and direct connection of the urine channel to the digester, slurry tank, distribution channels for the slurry or a slurry cart, advice on the utilisation of slurry, gas pipeline systems, burners and lamps. Women were specifically instructed during initial years in Tanzania but this process suffered when the GTZ social studies expert left the project.

By 1990 around 200 "biogas units" had been constructed directly by the BES or on its authority by trained craftsmen. In 1992 there were 600 biogas plants in the whole of Tanzania.

## **Special Energy programme**

Dissemination strategy and project structures underwent decisive changes mainly around 1990. These were chiefly a result of financial and personnel withdrawal of the GTZ from the BES and the subsequent extensive transfer of the project to the counterpart organisation. In the course of this transfer phase from 1990 to 1992 and with a further extension from 1992 to 1994, the project receives financial support within the scope of the *Special Energy Programme* (SEP) which apart from the biogas component also includes fuelwood-saving stoves. Personnel involvement of the GTZ is reduced to one person for both components and the main task of this person is to see that the locally provided funds of the BES are used for the purpose intended and the SEP funds are applied to overriding measures which the customer cannot finance (e.g. training).

## **Financing**

Orders which cannot be covered by the standardised range of plants and services and which necessitate additional research and development work have to be financed completely by the customer. This increased orientation towards privatisation of the BES has sent the costs for a Biogas Unit from around TSh 300,000 in 1989 to TSh 400,000 to 7000,000 according to the region. Despite this, the number of units constructed until 1992 has increased to about 400.

## **Further dissemination programmes**

Apart from the CAMARTEC dissemination programme there are two other relatively extensive dissemination programmes: one is being carried out by the church organisation (ELCT) in Arusha and one by the *Ministry of Water, Energy and Minerals* in Dar es Salaam. On all sides there is sporadic cooperation in the field of training and upgrading with the animal husbandry department of the *Ministry of Agriculture* in Arusha and the *Ministry of Water, Energy and Minerals* in Dar es Salaam which primarily supports the dissemination of biogas technology in the region of Dar es Salaam. It ensures training for private craftsmen, builds demonstration plants and is in charge of monitoring and evaluation.

There has been no cooperation with the active church organisation ELCT which has been active in dissemination since 1988. The reason may be the almost contrary dissemination concept of the ELCT in comparison to the BES. In ten decentral church centres there are contacts trained in biogas technology who coordinate advice, training of biogas craftsmen and construction etc. The target group is made up of farmers with at least two head of cattle. Chinese fixed-dome plants with conical fundamentals are disseminated. The farmers receive 50% of the investment costs as a credit on conditions depending on their socio-economic situation. To keep the investment costs low the farmer families are included in the construction of plants. The costs for a 12 m<sup>3</sup> plant, for example, amount to an average of TSh 100,000. Biogas accessories (lamps, stoves) are imported from India and China and are around half the price of those from CAMARTEC. CAMARTEC's commercially oriented, strictly standardised dissemination programme is considered by ELCT as not adapted to Tanzanian conditions as it only serves the rich farmers.

# **Geography, population and agriculture in Tanzania**

## **Geography**

Tanzania lies in the East of Africa between 1° and 12° south and between the Indian Ocean and the East African rift valley. From the eastern coast the land slopes upwards to the west where tableland and mountainous country 900 and 1,200 m are marked characteristics formed by the East and Central African rift valleys and volcanos which have formed in the rift zones. The highest of these volcanos is Kilimanjaro at 5,895 m which is also the highest mountain in Africa. A tropical-humid climate predominates along the coast whilst the interior of Tanzania has a moderate tropical highland climate. In the eastern rift zones and on the southeastern slopes of the volcanos precipitation of 1,500 mm to 2,000 mm occurs due to orographic rain with more than 10 wet months. Along the coast, the monsoon brings moderate rainfall (500 to 1,000 mm) with 5 to 6 wet months. The highland in the interior is relatively dry with 3 to 4 wet months and annual precipitation of below 500 mm.

## **Population**

According to official estimations in 1988, 23,997 million inhabitants live on 945,087 km<sup>2</sup> (25.4 inhabitants per km<sup>2</sup>). Although the population in urban areas is constantly rising, around 85% of the Tanzanian population lives in the country in approx. 8,700 villages. 98.5% of the population are Africans belonging to 120 different tribes. 1.5% of the population are Asian, Arabian and European.

## **Economy and agriculture**

According to the World Bank in 1992, the economic situation in Tanzania continued to deteriorate in the past year, and the country is now second on the list of the poorest countries in the world. Per capita income among the Tanzanian population fell from US\$ 130 in 1991 to US\$ 110. Reasons stated for this are, amongst others, the lack of incentives for agricultural production, industry not working to capacity which only contributes 8% of the GDP, a lack of consideration for environmental problems in economic development and a high population growth rate (1990: 3.5%).

The Tanzanian economy is primarily marked by agriculture. The agricultural sector contributes around 44% to the GDP and the majority of the population are dependent on this for their existence. In addition to providing food for the population, agriculture makes a contribution of almost 60% to earnings from exports. Important export products are coffee, cotton, cashew nuts and tea. 90% of cropland is cultivated by smallholders, the rest by export-oriented plantation and state-owned companies. 6% of the total area is arable land and 37% pastureland of which a considerable area can only be used occasionally for grazing (dependent on seasonal precipitation). Only about 2% of the arable land is irrigated. Mixed farming with arable farming and animal husbandry is not widespread in Tanzania. As the yields are centrally dependent on the quality of soil and on precipitation the best arable land is situated northeast of Kilimanjaro.

A reduction in reliance on foreign oil is the major priority as Tanzania had to spend 60% of its foreign currency income on purchasing oil up to 1985. For this reason the development and utilisation of domestic energy resources and the efficient utilisation of energy have been given a major priority in the second "Union" 5-year development plan from 1988-89/1992-93.

## **Environment**

According to the National Environmental Management Council and the 1992 World Bank Report, Tanzania is facing a series of very serious environmental problems. The central problem is an insufficient supply of water at all for the population and in particular, a supply of clean water. Erosion is leading to diminished fertility of the land. This is assumed to result in a 0.5 - 1.5% reduction annually in the GNP. Smoke emissions in the households stemming from the use of firewood, dung and straw as energy for cooking are already showing adverse effects on women and children. The World Bank Report compares this to a health risk of

smoking several packets of cigarettes per day and is taken far more seriously than the increasing air pollution in cities.

# Biogas technology in Thailand

## History

Up to 1982 there were approximately 1,000 biogas plants in Thailand which were built by various state and private organisations. Greatest involvement here was by the *Ministry for Public Health* with its *Sanitation Division* which had good infrastructure through the *Preventive Health Centres*, and which disseminated **fixed-dome plants** of the Chinese type. After discouraging experience with **floating-drum plants** mainly erected in Buddhist monasteries which had an average service life of less than two years according to a report in 1979, the emphasis was obviously changed to fixed-dome plants. Due to the high level of groundwater in the south, floating-drum plants were erected above ground and "red mud plastic" fermenters were built. Apart from these classic types of construction there were a large number of home developments and experiments which did not turn out to be suitable for dissemination. The activities have today all extensively died down or have been completely stopped.

## Thai-German Biogas Programme

In 1988, the **GTZ/GATE** began cooperation with the *Chiang Mai University in the Department of Mechanical Engineering* and the *Department of Agricultural Extension of the Ministry of Agriculture* in the form of the *Thai-German Biogas Programme*. Until 1992, 150 biogas plants were in operation of which some were large-scale plants for pig farms. The total potential of household plants is estimated to be approx. 200,000 in the 5 provinces.

The Thai-German Biogas Programme is assigned to the university and the *Department of Agricultural Extension of the Ministry of Agriculture*. Work division has, in fact, arisen whereby the university with its *Department of Mechanical Engineering* is responsible for R & D and for the larger-scale biogas plants and the *Ministry of Agriculture* with its *District Agricultural Extension Service* is in charge of disseminating the standardised household plants.

## Type of plant

The **CAMARTEC plant** from **Tanzania** was taken over with only minor changes. The plants, as a standard, are to be connected directly to stabling with a hard floor.

Household plants are offered in standard sizes of 8, 12, and 16 m<sup>3</sup> digester volume of which 12 m<sup>3</sup> is the most frequent. The standard ratio digester volume/gas storage volume amounts to 8:1. In addition to the household plants, larger units of 30 - 80 m<sup>3</sup> digester volume were built for pig farms according to the same technical principle to which two or three flat compensation chambers as vault constructions are connected.

## Geography, population and agriculture in Thailand

### Geography and population

Thailand, located between the 10° and 20° north, comprises an area of 513,000 km<sup>2</sup> and has a population of 56 million of which 85% belong to the Thai peoples. Its neighbouring countries are Burma in the northwest, Laos in the northeast, Cambodia in the east and Malaysia in the south.

The project area (5 provinces, about 12,000 km<sup>2</sup>, 4 million inhabitants) lies in the northeast with the centre of Chiang Mai which after Bangkok is the largest city in the country (150,000 inhabitants). The climate is tropical with temperatures of between 14° and 36°C. It is marked by a summer monsoon, the months of December to March are dry with only insignificant precipitation.

The areas important for the biogas dissemination programme are flat and lie at an altitude of about 200 m above sea level. Mostly rice, maize and manioc are cultivated on the fields. The settlements are mostly scattered villages.

### **Economy and agriculture**

Thailand belongs to the countries with an average income in the lowest category. The GNP amounted to 1,420 US\$ in 1990 and has grown by 7.6% annually in the last decade. The services sector made a contribution to the GDP of 48%, industry 39%, processing industry 26% and agriculture only 12%. 35% of all imports are capital goods, the largest proportion of exports comes from agriculture and forestry (rice, maize, tapioca, vegetables, spices, caoutchouc, jute and teak). Thailand is the largest rice exporter throughout the world. All chemical fertilisers and oil products have to be imported. Electricity is exported to Laos.

In addition to production for exports, agriculture is expected to secure nourishment for the domestic population. The supply of wheat and chiefly rice is already sufficient for the home market. The production of pork and poultry is to be increased further. Pig-breeding farms are the central target of the biogas dissemination programme.

The 5-year plant begun in 1992 is devoted to the promotion of organic fertiliser. It is to be intensified mainly by improved training of the agricultural extension officers.

### **Environment**

Environmental protection is a subject which is gaining in interest among the public. A new law on keeping the air and water clean is to be passed in 1992. This law applies centrally to the agroindustry and to large and medium-scale animal husbandry farms. At present however there is no extension service linked to the Ministry for the Environment.

## **Biogas technology in Tunisia (Sejenane, El Kef)**

### **History**

The first biogas activities date back to the Tunisian-German cooperation in the Sejenane region in 1982 when an 11 m<sup>3</sup> **floating-drum plant** was built by the project *Développement Régional à Sejenane*. In autumn 1983 an agreement was concluded between this project and the *Ecole Nationale d'Ingénieurs* (ENIT) in which ENIT engaged to carry out research into and dissemination of biogas technology for this region. In 1986 the first **fixed-dome plant** (6 m<sup>3</sup>) was built. Until the engineer who had mainly been responsible for biogas at the ODESYPANO left in July 1987, a further 7 fixed-dome plants (BORDA models) had been constructed.

At the end of 1987, ODESYPANO expressed a wish to establish a cooperation with the *Entreprise Tunisienne des Activités Pétrolières* (ETAP) and the *Agence de Maitrise de l'Energie* (AME) to reassume biogas activities and this was realised in 1989 by pilot measures of the *Special Energy Programme Tunisia*. In this phase, the non-functioning plants in the region were rehabilitated and 10 further biogas plants were built. The centre of activities was constituted, besides modification of the technical side (mainly gas appliances), by training measures and slurry experiments. From December 1991 to December 1992 a further measure was carried out in El Kef with the construction of another 11 demonstration plants (between 16 and 25 m<sup>3</sup>) and the establishing of a *Biogas Office* at ODESYPANO in Le Kef. In April 1992 the *Special Energy Programme* withdrew from biogas activities. Although the ODESYPANO general and regional managements concerned had stated their interest in continuing biogas dissemination, activities in this area almost came to a complete standstill. Both central sources of know-how saw their demands for a description of tasks as not having been fulfilled in accordance with their status and consequently searched for other areas of activity.

### **End of the Special Energy Programme**

The dissemination activities in Sejenane as well as in El Kef almost came to a complete standstill when the direct *Special Energy Programme* involvement ended. In autumn 1992 plants were planned and built only in isolated cases. This decline is in direct conflict with the explicitly formulated interest of decision-makers (mainly at the ODESYPANO) in biogas technology. That this interest and the positive demonstration effects of plants built have not led to consolidation of a sustainable dissemination structure indicates the presence of a multi-level socio-economic complex of problems.

## **Geography, population and agriculture in Tunisia (Sejenane, El Kef)**

### **Geography and population**

The project regions of Sejenane and El Kef belong geographically to the Le Tell region. The border to the north and east is formed by the Mediterranean coastline and to the south, the 400 mm precipitation limits. Whilst El Kef is administratively its own *gouvernorat* with an area of approx. 5,000 km<sup>2</sup>, Sejenane is in the *gouvernorat* of Bizerte and comprises an area of approx. 400 km<sup>2</sup>.

The climate in Sejenane is influenced by the Mediterranean and has a mean annual temperature of 17.8°C with an average in July of 27°C and in January of 10°C. Annual precipitation falling mostly between October and March amounts to between 800 and 900 mm. According to the census in 1984, 33,212 people lived in the region.

The climate in the region of El Kef belonging to the Tell Haute region, is continental and semi-arid in the south. In the capital of the El Kef *gouvernorat*, mean annual precipitation amounts to 512 mm. Average temperatures are between 7.1°C in January and 26.5°C in

July. Annual precipitation is subject to considerable fluctuation making it a serious factor of uncertainty for agriculture. Approx. 250,000 people lived in the Le Kef region in 1984.

## **Economy and agriculture**

In 1990 the GDP at factor cost of the well-differentiated Tunisian economy comprised: agriculture and fisheries 16.4%, oil and gas production 6.9%, tourism 4.5%, processing industry 16.8% and services 47.1% (including public administration). Fluctuations on the oil market and in the tourist industry and drought are considered to be the factors of uncertainty in an economy which is aiming for a growth rate of 6% for the 5-year plan from 1992 to 1996. Although the proportion of agriculture in Tunisia has declined constantly since independence (from 56% in 1960 to 14.1% in the drought years 1883), it still occupies a key position in development planning: reduction of cereal imports (1990: 191 million TD, 1 TD = 1.12 US\$), expansion of the export sector and stabilisation of rural areas marked by country-to-city migration by means of integrated rural development. Rain-fed agriculture is predominant (approx. 9 million hectares) which partly explains the considerable fluctuations in agricultural yields. Irrigated agriculture is practised on only approx. 250,000 hectares constitutes a significant part of the national overall yield. Extensive irrigation projects are to reinforce its position further. Despite the inefficiency complained about on all sides, the parastatal agricultural development bodies have contributed significantly to progress in dairy and meat production. 40% and 90% respectively of domestic demand is met by home production.

An emphasis in Tunisian development policy will continue - despite over-proportionally increasing development costs - to be the electrification of rural areas by the Société Tunesienne de l'Electricité et du Gaz (STEG). Despite this, there are large areas of rural regions - particularly scattered settlements - which cannot hope for a connection to the central electricity supply. Despite this long-term gap which will remain, the STEG has showed little interest in supply concepts involving renewable energy sources.

The project region of Sejenane has been undergoing profound economic and social transformation in the last twenty years. Whilst in 1984 9.5% of the population were living in small town settlements, in 1966 settlement was exclusively in the rural milieu. In 1966 settlements in a village structure with more than 10 houses made up 12%, in 1984 it had already reached 29%. Parallel to this change, there was a transformation of the once communal property into individual ownership. The number of farms with a title to their own property rose from 891 in 1963 to 3,435 in 1984. The economy of the region has begun to diversify. More and more farmers are finding additional occupations with the state, in crafts and in trade. This shift was mainly brought about by development efforts to promote the penetration of rural areas by the monetary economy. Nevertheless, bartering is still a dominant element of the regional economy. At the same time, formal financing systems are underdeveloped. Monetary income in the region is weak. Less than 5% of households have an annual income in excess of 3,000 DT. Animal husbandry, dominant in the region due to poor soils has undergone great qualitative and quantitative improvement due to efforts by the Office de Developpement Sylvo-Pastoral de Nord Ouest (ODESYPARNO) and thus, dairy farming and meat production have been expanded. Nevertheless, underemployment and country-to-city migration remain characteristic for this structurally weak region.

2,000 years ago the Le Kef region was the "granary" for the Roman Empire and despite the increasing degradation of natural resources, this still marks agricultural structure today. Of the total agricultural area amounting to 380,000 hectares, approx. 250,000 hectares are cultivated. More than 55% of cropland is reserved for cultivating cereals (hard wheat, wheat, barley). Intensification of agricultural production is restricted not only by natural conditions but also by the limited working capital/equipment available. Animal husbandry is semi-extensive. Together with cereal production, animal husbandry makes up over 90% of added value in agriculture. In 1987 the number of cattle amounted to 51,200 head. The number of sheep was 538,142 and of goats 43,140. Approx. 4,000 farmers in the region have more than 4 animals. Cattle raising is mostly carried out in the northern delegations where the water supply is far better than in the south.



# Biogas technology in Vietnam

## Biogas utilization

The utilization of biogas is common in the Mekong Delta and sustainable in animal husbandry as a supplement, to farm activities on a household-scale (up to about 20 pigs, for instance). Using gas instead of other types of fuel is well accepted by local farmers because of its savings on fuel and the convenience of biogas compared with fire wood or kerosene. However, in the Mekong delta, there is much less attention and attraction from the owners of larger scale animal farms to the utilisation of biogas and, in consequence, anaerobic treatments. Animal farms with a scale of 100-200 pigs and about 1000-5000 chickens become more and more common in Vietnam.

Waste treatment, especially with anaerobic technology, is needed to be given more attention in the operation of intensive and specialized farms, which cause more pollution than the micro scale. The biogas digester seems to be the most suitable solution to treat the waste from animal farms. However, in this small and medium scale, the amount of biogas produced is much higher than the domestic demand for cooking, lighting etc.

A large surplus of biogas is expected. Only when some economical ways to use this biogas can be introduced, farm owners will be willing to pay for anaerobic technology.

A new study showed, that

- running engines with biogas can be technically and economically feasible and suitable for farms with 80 pigs or more.
- burning biogas for direct-heated driers can be feasible for farms with 120 pigs or more. Futural economical feasibility is expected.
- burning biogas for driers with heat exchanger can be technically feasible for pig farms with 120 animals, but not economically.

## The benefits of biogas systems within integrated farming systems

The original intensive farming model VAC integrates crops (V), fish (A) and pigs (C) into a symbiotic system that reduces the dependence on external inputs, while increasing productivity. However, the system does not provide a proper treatment of animal waste.

The VACB farming model is, therefore, a much improved version of VAC. It yields more profit for the farm while improving the whole environment. In order to contribute to poverty alleviation, hunger eradication and ensure sustainable rural development, the Renewable Energy Center (REC) of Can Tho University in the Mekong Delta has established about 20 VACB models.

After three years complementation (1993-1996) the following conclusions have been achieved:

- To establish VACB system, the role of well trained pilot VACB owners, the extension workers and self-help group leaders should be to cooperate in a combined spirit in order to support the poor.
- The target group is to upgrade members in the self-help group, to become members of VAC groups and later owners of integrate farming systems, which include biogas system (B). This can increase the family income considerably, contribute to the provision of a renewable energy source, and provide fertilizer in the rural areas.
- Last but not least, the biogas system diminishes organic pollution in rivers and channels, which is of great importance in the Mekong River Delta.
- In order to reach this target, the assistance from the government, universities, and the local authorities to organize the farmer's self-help group, is the most important factor.

# **Geography, population and agriculture in Vietnam**

## **Geography and population**

The Socialist Republic of Vietnam is a multiethnic state with 79 Mill. inhabitants (87% Kinh, 13% other nationalities) and an area of about 329.566 km<sup>2</sup>. With an average income of about 200 US\$ per person, Vietnam is one of the poorest of the Asian countries. The population increases 2,2% every year.

The objective of the national planning for the future is an income of 400 US\$ per person and a reduced increase of population of 1,7%. The agriculturally utilized area of 70.000 ha (1993) shall be increased to 122.000 ha.

## **Economy and agriculture**

In 1994, the economic growth of the vietnamese industry was 11,5% and in 1995 13,1%. The growth in the service sector was 9,7% (1994) and 11,9% (1995).

25 million tons of grain were produced in 1993. Predominant exports are rice, latex, coffee, tea, peanuts, meat, cashews and silk-yarn.