ENVIRONMENTAL ASSESSMENT

OF THE

CHINA ECO-FARMING PROJECT

Submitted by:

Ministry of Agriculture
People’s Republic of China
April 2007
# CONTENT

**EXECUTIVE SUMMARY** ................................................................. 2

1  **INTRODUCTION** ........................................................................... 5
1.1  **GENERAL** .................................................................................. 5
1.2  **THE STUDY AREA** ............................................................... 5
1.3  **PURPOSE AND OBJECTIVES OF THE STUDY** ...................... 6
1.4  **ASSESSMENT SCOPE AND PERIODS COVERED** .................. 6

2  **POLICY, LEGISLATION, INSTITUTIONAL & REGULATORY FRAMEWORK** ...... 7
2.1  **LEGISLATION** ........................................................................... 7
2.2  **TECHNICAL CRITERION** ..................................................... 7
2.3  **PROJECT DOCUMENTS** ....................................................... 8
2.4  **ASSESSMENT CRITERIA** ....................................................... 8

3  **PROJECT DESCRIPTION** .............................................................. 11
3.1  **PROJECT AREA** ....................................................................... 11
3.2  **PROJECT GOALS** ............................................................... 11
3.3  **PROJECT CONTENT** ............................................................... 12

4  **BIOPHYSICAL AND SOCIO-ECONOMIC ENVIRONMENT** ...................... 16
4.1  **BIOPHYSICAL ENVIRONMENT** .......................................... 16
4.2  **SOCIO-ECONOMIC ENVIRONMENT** ................................... 18

5  **PUBLIC CONSULTATIONS** .......................................................... 21
5.1  **PUBLIC PARTICIPATION MODE AND CONTENT** .................. 21
5.2  **RESULT ANALYSIS** ............................................................. 23

6  **POTENTIAL IMPACTS OF ECO-FARMING PROJECTS** ...................... 27
6.1  **POTENTIAL IMPACTS AT HOUSEHOLD LEVEL** ................. 27
6.2  **ENVIRONMENTAL IMPACTS AT VILLAGE LEVEL** ............ 33
6.3  **POTENTIAL ENVIRONMENTAL RISK** ................................ 35

7  **MITIGATION AND TRAINING PLAN** ........................................ 39
7.1  **MITIGATION PLAN** ............................................................. 39
7.2  **TRAINING REQUIREMENT** .................................................. 43

8  **ENVIRONMENTAL SUPERVISION REQUIREMENTS AND INDICATORS CHECKLIST** ................................................................. 45
8.1  **MONITORING PLAN** ............................................................ 45
8.2  **MONITORING INDICATORS** ................................................ 46

9  **GOOD MANAGEMENT GUIDELINE** .......................................... 47

10  **CONCLUSIONS AND RECOMMENDATIONS** ................................ 48
10.1  **CONCLUSION** ................................................................. 48
10.2  **SUGGESTIONS** ................................................................. 49
EXECUTIVE SUMMARY

Eco-Farming Project is granted by the World Bank and organized by Ministry of Agriculture of PRC and implemented by Anhui Agriculture Committee, Chongqing Agriculture Bureau, Guangxi Agriculture Bureau, Hubei Enshi Autonomous State Ecology and Energy Bureau and Hunan agricultural bureau. The construction period is planned for 5 years from July 2007 to July 2012.

Develop integrated rural high effective eco-energy construction model through supporting farmers of the project area to more effectively utilize the earth and bio-energy resource, and to make the household clean, courtyard economy high efficient and agriculture production non-polluted. Further reform the rural ecological environment and production condition, improve integrated agriculture production capability, increase peasant income and improve peasant living level so as to realize the high uniform of rural ecological benefit, economic benefit and social benefit, and build socialism new countries in which the human being and nature are harmonious, and the economy, society and ecological condition can coordinately develop.

The proposed project include 538,650 farmer households in 64 villages (cities or district) of 5 provinces (Autonomous State). Thereinto, 92,800 households live in Anhui, 75,000 households in Chongqing, 80,850 households in Guangxi, 200,000 households in Hubei, and 90,000 households in Hunan.

The construction contents of the project area are mainly divided into 3 parts:

1. Construction of integrated agriculture ecological system. It is mainly one tank and three modifications, which establishes courtyard ecological household tied by biogas digesters including building biogas digester, developing organic fruit, vegetable, feeding crop and livestock breeding, aquiculture to help farmers alleviate poverty and become prosperous and refine production and living conditions of farmers by the modification of kitchen, toilet, and barn, etc.

2. Technical promotion and service system construction. Mainly construct and perfect the 4-level (province, city, county and village) agriculture technical promotion network form rural eco-energy technique promotion service system, rural ecological environment monitoring system, and provide the safeguard of technique, production, market and policy.

3. Construction of project management, monitoring and evaluation system. Establish project management information network and project monitoring evaluation system. Train the related staff of the project management departments about the project implementation, capital management, payment, purchase, report and foreign, etc. to improve the capability of project control and the management level of the project managers.

In addition, the project will also seek support from Clean Development Mechanism (CDM). CDM is a kind of mechanism that provides an opportunity for developed countries and developing countries to work together to reduce greenhouse gas (GHG) emission. Under the mechanism, developed countries will purchase CERs (Certificated Emission Reductions) from developing countries in order to achieve
their GHG emission reduction requirement made by Kyoto Protocol. For this project, it will reduce the methane emission by changing the traditional manure management methods and recovering methane for the households’ thermal energy needs, such as cooking and lighting, through developing biogas digesters, which will use animal manure as the raw materials. It means that household farmers can get a stable revenue stream if the carbon trade comes to be true. In regards of the specific characteristic of the Eco-farming project, it will prepare and apply for CDM support province by province. And Enshi prefecture of Hubei province is selected as the first demonstration site.

Environmental impacts of this project are assessed in accordance with China's relevant laws and regulations, technical standards, evaluation criteria and guidelines of World Bank. Survey on natural and socio-economic conditions of the project has been conducted. According to relevant provisions of the State Environmental Protection Administration of China and the World Bank, relevant information environment assessment outline are disclosed on websites of Agriculture Department of each project provinces. Environment meetings participated by Non-government organization and relevant government organization, as well as interested people. The working team interviewed Farmers to get the base information, such as family population, use of energy and conditions of producing and living. Opinions of farmers are collected by Questionnaire survey. 200 questionnaires are sent out in each province and survey results show that 96% of the public are for the project.

Potential environmental impacts of the project are evaluated in village and household level. Results show that impact on the environment of entire operation of the project in the whole process is positive, which is manifested in the following aspects:

1. The project will change the energy structure of farmers. Traditional coal, straw and firewood are to be replaced by clean methane, thus greenhouse gases (CO2, CH4) and polluting gases (SO2 and dust) emissions as well as deforestation are to be reduced and forest can be protected.

2. Reasonable application of biogas fertilizer will reduce pollution on soil and water caused by direct discharge of animal waste, will improve soil fertility by reducing application of fertilizer and pesticide, will improve the quality of agricultural products, promote green food production and increase farmers’ income from planting and breeding.

3. Construction of biogases, modification of animal shed, toilet, and kitchen will improve sanitary conditions of farmers’ courtyard, reduce spread of the disease, and improve their quality of life and health.

During the construction period, digging of biogas digester and construction of village path will discharge solid wastes and noises. However, these negative impacts will be short-lived, and with the end of the construction they will stop.

There are certain environmental risks during operation of the project and they are:

1. Previous experience indicate that in areas where adequate number of technical staff are no present and enough technical training is not provided to the farming communities on use and maintenance of biogas systems, there is a potential risk of
unnoticed gas leak that has a potential risk of causing explosions or asphyxiation
(2) There are a lot of pathogens in the night soil and livestock manure. During the process of anaerobic fermentation, the pathogens cannot be completely killed, but can be reduced to acceptable levels, if adequate retention time is allowed to reduce potential risk to human health.
(3) After adequate fermentation of manure in the biogas digester, the levels of COD and NH₃-N are still very high. If the bio-liquid or bio-solids are applied in very large quantities to the field as a basal application, there is a risk of potentially polluting water bodies.
Mitigation measures for adverse impact and environmental risk are proposed in this report including protective measures during the construction period, prevention of gas leakage, pathogenic microbes spreading, over use of the biogas fertilizer, and environmental monitoring program.
To enable farmers use biogas and its products correctly, and to avoid the occurrence of the adverse environmental impacts, the central project office compiles the "good practices guidance" on aspects of construction and maintenance of biogas digester, proper use of biogas and correct application biogas fertilizer for farmers and technical staff.
1 INTRODUCTION

1.1 General

Eco-Farming Project is granted by the World Bank and organized by Ministry of Agriculture of PRC and implemented by Anhui Agriculture Committee, Chongqing Agriculture Bureau, Guangxi Agriculture Bureau, Hubei Enshi Autonomous State Ecology and Energy Bureau and Hunan agricultural bureau. The construction period is planned for 5 years from July 2007 to July 2012.

Develop integrated rural high effective eco-energy construction model through supporting farmers of the project area to more effectively utilize the earth and bio-energy resource, and to make the household clean, courtyard economy high efficient and agriculture production non-polluted. Further reform the rural ecological environment and production condition, improve integrated agriculture production capability, increase peasant income and improve peasant living level so as to realize the high uniform of rural ecological benefit, economic benefit and social benefit, and build socialism new countries in which the human being and nature are harmonious, and the economy, society and ecological condition can coordinately develop.

The proposed project includes 538,650 farmer households in 64 villages (cities or district) of 5 provinces (Autonomous region). For specific description, 92,800 households live in Anhui, 75,000 households in Chongqing, 80,850 households in Guangxi, 200,000 households in Hubei, and 90,000 households in Hunan.

1.2 The Study Area

The Environmental Assessment (EA) is one of important methods, which prove the feasibility of project by controlling the potential environmental pollution sources and optimizing the programs of environmental protection of projects. To be most important, The EA is also necessary in order to ensure that the Project is designed to avoid or minimize any adverse impacts and risks the Project could cause to local environment and ecology. The EA would provide guidance during project preparation to re-design project activities or propose mitigation measures to lessen any adverse environmental impacts and risks the project may have.

The EA will be conducted in order to make contributions to the Project design in the following aspects: (a) To investigate local environmental situations so as to ensure that the proposed Project interventions are suitable for local development; (b) To identify the potential pollution sources and key points of production process to pollution;(c) To optimize the production process by amending the production process or supplementing measures of environmental protection; (d) To evaluate the overall benefits and adverse impacts of project to local environmental improving; and (e) To establish baseline environmental monitoring indicators for project evaluation.
1.3 Purpose and Objectives of the study

The EA aims of the Eco-farming Project are:

1. To ensure that the project benefits local environmental protection and ecological improving, especially farmers' households and living surrounding bettering;

2. To strengthen the Public Participation and negotiation of Environmental Assessment of the Eco-farming project, especially including the local farmers, non-governments and other vulnerable groups, in all stages of the project cycle.

3. The Environmental Assessment (EA) of the Eco-farming Project would be prepared to meet the requirements of the World Bank’s project appraisal process. The information obtained from the EA will be shared and discussed with the rest of the preparation team and used as input into the final design of the project.

1.4 Assessment Scope and Periods Covered

1.4.1 Assessment Scope

The study area covered in the EA study covers all the project area in five provinces.

1.4.2 Periods Covered

The environmental assessment covers different phases of project implementation including:

Implementation/Construction period (5 years, 2007.7-2012.7)

Operation Period (12 Years, 2012.8-2024.8)
2 POLICY, LEGISLATION, INSTITUTIONAL & REGULATORY FRAMEWORK

2.1 Legislation

(1) Environment Protection Law of the PRC (December 26th, 1989)
(2) Environment Influence Evaluation Law of the PRC (December 28th, 2002)
(3) Agriculture Law of the PRC (December 28th, 2002)
(4) Prevention and Treatment Law of air pollution of the PRC (April 29th, 2000);
(5) Prevention and Treatment Law of Water Pollution of the PRC (May 15th, 1996);
(6) Prevention and Treatment Law of Solid Waste Pollution of the PRC (April 1st, 2005)
(7) Prevention and Treatment Law of Noise Pollution of the PRC (October 29th, 1996)
(8) Water and Soil Conservation Law of the PRC (June 29th, 1991)
(11) The People's Republic of China livestock farming method (December 30th, 2005)
(14) List of Construction Project Environmental Protection Classification Management (Order No. 14 of SEPA, October 2002)
(15) Regulations of Livestock Waste Management of Livestock (May 8th, 2001)

2.2 Technical Criterion

(1) The World Bank Policies 4.01, 4.04, and 4.10;
(2) The World Bank policy on disclosure of information;
(3) Environment impact assessment technology guidance - General Outline, HJ/T2.1-1993;
(4) Environment impact assessment technology guidance, Atmosphere Circumstance, HJ/T2.1-1993;

(5) Environment impact assessment technology guide rule-Surface Water Circumstance, HJ/T2.3-1993;

(6) Environment impact assessment technology guidance -Acoustical Environment, HJ/T2.4-1995;

(7) Environment impact assessment technology guide rule-acoustical environment-non pollution ecological effect;

(8) Specification for check and acceptance of the quality for Household Biogas digester, GB/T4751-2002; and

(9) Sanitary standard for the non-hazardous treatment of Feces, GB 7959-87.

2.3 Project Documents

(1) China New country ECO-FARMING Enriching People Project Feasibility Study Report Sept., 2006

(2) The suggestion for New country ECO-FARMING Enriching People Project of Anhui province, Chongqing city, Guangxi Zhuang Autonomous Region, Hubei Enshi Autonomous Area and Hunan province, Sept., 2006

(3) Terms of References (TOR) for an Environmental Assessment of the Project

(4) The commission letter to China Agriculture University Environmental Influence Evaluation Center of Foreign Economy Cooperation Center of Ministry of Agriculture

2.4 Assessment Criteria

According to the environmental function zoning and detailed project location of every province project area, select the suitable quality standard and discharge standard, and the local (province or state) Environment Protection Agency sends letter to confirm the grade of environment standard.

2.4.1 Environment Quality Standard

(1) Surface Water

Refer to Environment Quality Standard for Surface Water (GB3838-2002).

According to the environmental function zone classified by local environmental protection agency, Classes I, II, III, IV and V standard are implemented respectively.(Class I for water body in Nature Protection Region of National or river sources, Class II for Grade One Protection of Drinking Water Source, Class III for Grade Two Protection of Drinking Water Source or fishery aerea, Class IV for water used in industry or amusement, Class V for water used in agriculture or landscape.)
(2) Ground Water

Refer to Environmental Quality Standard for Ground Water (GB/T14848-93).

Generally Grade III standard is implemented in project area. (Class III for water body used as drinking water source or in agriculture and industry)

(3) Environment Air

Refer to Ambient Air Quality Standard (GB3095-1996, revised on Jan. 6th, 2000).

According to environmental function zone classified by local government. Classes I and II standard are implemented respectively. (Class I for nature protection region, Class II for inhabitation region or region mixed by living, commerce and education, or rural area.)

(4) Environment Noise

Refer to Standard of environmental noise of urban area (GB3096-93).

Country residential district implements Class 1 standard and the main traffic lines (railway and high way) implement Class 4 standard.

(5) Soil

Refer to Environmental quality standard for soils (GB 15618-1995).

Class 2 standard is implemented in project area. (Class 2 is the limit value to protect public health and agriculture production)

2.4.2 Discharge Standard

(1) Waste water

Refer to Integrated wastewater discharge standard (GB 8978-1996).

According to the water body classification (same to the Surface Water) which accepts wastewater, deferent standards are adapted. Grade one standard is implemented, When wastewater is discharged into Class III water body, Grade Two standard is implemented, When wastewater is discharged into Class IV and V water body, and Grade Three standard is implemented, When wastewater is discharged into sewage pipes which connect with wastewater treatment building. Forbid wastewater to be discharged into Class I, II water body and some Class III area appointed by the government.

(2) Air pollutant

Refer to Integrated emission standard of air pollutants (GB16297-1996).

According to the environmental function zone classified by local environmental protection agency, Grade One and Two standards are implemented respectively. (The classification is same as Environment Air). Class I zone implements Grade One standard, and Class II zone implements Grade Two standard.

(3) Odor pollutants
Refer to Discharge standard of pollutants for livestock and poultry breeding (GB18596-2001).

Odor exhaust air concentration should be below 70.

(4) Noise

Refer to Noise limits for Construction site (GB12523-1990) in the construction period.

(5) Livestock and poultry Manure

Refer to Discharge standard of pollutants for livestock and poultry breeding (GB18596-2001).

Roundworm ovum Death rate is above 95%, the number of bacillus coli is above $10^5$. 
3 PROJECT DESCRIPTION

Eco-Farming Project is organized by Ministry of Agriculture of PRC and implemented by Anhui Agriculture Committee, Chongqing Agriculture Bureau, Guangxi Agriculture Bureau, Hubei Enshi Autonomous State Ecology and Energy Bureau and Hunan agricultural bureau. The construction period is planned for 5 years from July 2007 to July 2012.

3.1 Project Area

The proposed project includes 538,650 farmer households in 64 villages (cities or district) of 5 provinces (Autonomous State) - Anhui, Chongqing, Guangxi, Hubei and Hunan are included in the project area, which mainly spreads on the plains along rivers and gentle slope hilly districts whose water and soil resource are good and have great development potential. While the farmer’s daily main energy resource is firewood and the water and soil erosion problem is serious with relatively abundant plant and animal waste material.

<table>
<thead>
<tr>
<th>Province</th>
<th>County</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhui</td>
<td>Feidong, Tongling, Guichi District of Chizhou City, Qingyang, Quanjiao of Chuzhou City, Tianchang, Yixiu of Anqing City, Taihu, Huaining, Huoshan of Liuan City, Huoqu, Shou, Guangde of Xuancheng City, Ningguo, Jing, Jixi, Huangshan of Huangshan City, Duo, etc.</td>
<td>18</td>
</tr>
<tr>
<td>Chongqing</td>
<td>Wanzhou, Fuling, Changshou, Jiangjin, Hechuan, Yunyang, Kai, Zhong, Bishan, Wulong, Liangping and Dianjiang.</td>
<td>12</td>
</tr>
<tr>
<td>Guangxi</td>
<td>Yao Autonomous County of Gongcheng, Pingle, Fuchuan, Cangwu, Xing'an, Bobai, Luchuan and Fangcheng District.</td>
<td>8</td>
</tr>
<tr>
<td>Hunan</td>
<td>Wangcheng, Ningxiang, Xiangyin, Lixian, Hengnan, Changning, Xiangtan, Lingling, Lengshuitan, Linwu, Yizhang, Longhui, Wugang, Yongding, Cili, Huayuan, Linli and Youxian.</td>
<td>18</td>
</tr>
<tr>
<td>Hubei</td>
<td>Enshi, Jianshi, Badong, Lichuan, Xuan'en, Xianfeng, Laifeng and Hefeng.</td>
<td>8</td>
</tr>
</tbody>
</table>

3.2 Project Goals

Develop integrated rural high effective eco-energy construction model through supporting farmers of the project area to more effectively utilize the earth and bio-energy resource, and to make the household clean, courtyard economy high efficient and agriculture production non-polluted. Further reform the rural ecological environment and production condition, improve integrated agriculture production capability, increase peasant income and improve peasant living level so as to realize the high uniform of rural ecological benefit, economic benefit and social benefit, and build socialism new countries in which the human being and nature are harmonious, and the economy, society and ecological condition can coordinately develop.
3.3 Project content

3.3.1 Project content classification

The construction contents of the project area are mainly divided into 3 parts:

1. Construction of integrated agriculture ecological system. It is mainly one tank and three modifications, which establishes courtyard ecological household tied by biogas digesters including building biogas digester, developing organic fruit, vegetable, feeding crop and livestock breeding, aquiculture to help farmers alleviate poverty and become prosperous and refine production and living conditions of farmers by the modification of kitchen, toilet, and barn, etc.

2. Technical promotion and service system construction. Mainly construct and perfect the 4-level (province, city, county and village) agriculture technical promotion network form rural eco-energy technique promotion service system, rural ecological environment monitoring system, and provide the safeguard of technique, production, market and policy.

3. Construction of project management, monitoring and evaluation system. Establish project management information network and project monitoring evaluation system. Train the related staff of the project management departments about the project implementation, capital management, payment, purchase, report and foreign, etc. to improve the capability of project control and the management level of the project managers.

In addition, the project will also seek support from Clean Development Mechanism (CDM). CDM is a kind of mechanism that provides an opportunity for developed countries and developing countries to work together to reduce greenhouse gas (GHG) emission. Under the mechanism, developed countries will purchase CERs (Certificated Emission Reductions) from developing countries in order to achieve their GHG emission reduction requirement made by Kyoto Protocol. For this project, it will reduce the methane emission by changing the traditional manure management methods and recovering methane for the households’ thermal energy needs, such as cooking and lighting, through developing biogas digesters, which will use animal manure as the raw materials. It means that household farmers can get a stable revenue stream if the carbon trade comes to be true.

3.3.2 Construction contents in each province

Table 3.2 presents a summary of the proposed construction activities in each province.

<table>
<thead>
<tr>
<th>Province</th>
<th>Farmer household</th>
<th>Basic construction scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhui</td>
<td>9.28</td>
<td>The detailed construction contents is building 92,800 Eco Farming households, mainly construct 8m³ biogas digester and its accessory</td>
</tr>
</tbody>
</table>
facilities and equipments. Renovate or construct kitchen, toilet and barns. Rebuild or improve 1 Mu plantation and field water conservation, roads, etc. facilities. Planting organic crops such as grain, fruit, tea and vegetable, etc. Rebuild or repair 10m² animal shed in order to make every household have 3-5 pigs.

<table>
<thead>
<tr>
<th>Province</th>
<th>Rate</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chongqing</td>
<td>7.5</td>
<td>Newly increase 75,000 biogas systems; rebuild kitchen in 750,000 households, rebuild toilets in 750,000 households and rebuild animal sheds in 750,000 households; Develop plantation and build up 37,500 Mu of prime mandarin garden, 30,000 Mu vegetable base station and 7,500 Mu of traditional Chinese medical material garden.</td>
</tr>
<tr>
<td>Guangxi</td>
<td>8.085</td>
<td>65850 biogas digesters with volume of 8 m³ and 15,000 tanks with the volume of 10 m³. 80850 modifications of the kitchens, toilets and barns, eco-farming system.</td>
</tr>
<tr>
<td>Hubei</td>
<td>20</td>
<td>200,000 biogas digesters with volume of 8m³. Rebuild or modify 4000,000 m² kitchens, 800,000 m² toilets, and 3000,000 m² animal shed.</td>
</tr>
<tr>
<td>Hunan</td>
<td>9.0</td>
<td>90,000 households of 5 different courtyard ecological eco-models tied by biogas digesters will be built up including construction of biogas digesters, improvement of kitchen, toilet and animal shed; development of organic fruit, vegetable, breeding crops, livestock breeding and aquiculture.</td>
</tr>
<tr>
<td>Total</td>
<td>53.865</td>
<td></td>
</tr>
</tbody>
</table>

After the project is completed, there will be 538,650 newly built household using biogas in the 5 provinces which can provide 119,140,000 m³ biogas and 7,305,000 tons biogas liquid and biogas residue. 540,000 tons nutrition content (N, P, K) could be saved.

Consult table 3-3 for the detailed products scheme of every province.

### Table 3-3 Products scheme of the project

<table>
<thead>
<tr>
<th></th>
<th>Unit</th>
<th>Anhui</th>
<th>Chongqing</th>
<th>Guangxi</th>
<th>Hubei</th>
<th>Hunan</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newly increased biogas household</td>
<td>10³ household</td>
<td>92.8</td>
<td>75</td>
<td>80.85</td>
<td>200</td>
<td>90</td>
<td>538.65</td>
</tr>
<tr>
<td>Newly increased biogas</td>
<td>10³ m³</td>
<td>3.248</td>
<td>2.722</td>
<td>2.709</td>
<td>6</td>
<td>4.05</td>
<td>18.729</td>
</tr>
<tr>
<td>Newly increased biogas liquid and biogas residue</td>
<td>10³ ton</td>
<td>928</td>
<td>790</td>
<td>2287.5</td>
<td>3800</td>
<td>1800</td>
<td>9605.5</td>
</tr>
<tr>
<td>N, P, K content in slurry</td>
<td>10³ ton</td>
<td>89</td>
<td>72</td>
<td>87</td>
<td>193</td>
<td>98</td>
<td>540</td>
</tr>
<tr>
<td>Increased fruit yield</td>
<td>10³ ton</td>
<td>4.379</td>
<td>67.5</td>
<td>17.24</td>
<td>60.2</td>
<td></td>
<td>149.32</td>
</tr>
<tr>
<td>Increased vegetable</td>
<td>10³ ton</td>
<td>3.608</td>
<td>90</td>
<td>31.84</td>
<td>55.4</td>
<td></td>
<td>180.84</td>
</tr>
</tbody>
</table>
### 3.3.4 Eco-Farming project process

The farmer eco-farming household is a kind of production model combined courtyard economy with ecological agriculture, which optimizes the biogas, solar energy, breeding and crops production, and realizes the multi-degree energy utilization and high efficient product model with benign circulating material by the biogas technology.

It is based on land resource and human resource, uses solar energy as power, biogas as connection and combines breeding and planting. Through the bio-energy switch technique, biogas digester, animal shed, toilet, water heater and bathroom are integrated to form a comprehensive utilization system consisting of ecological agriculture development and green energy. The system includes an animal shed, a biogas digester built under the animal shed and the toilet connected with biogas digester which deals with human and animal feces automatically entering the tank which provides a better sanitation environment to farmers.

In addition to produce biogas, the key function of biogas digester is produce biogas liquid and biogas residue which can be used as prime organic fertilizer in plantation to raise the output and quality of the production. The plantation area varies from 1 to 15 Mu according to the actual situations of the farmer household. Crops in plantation include fodder grass, feed grain, grain, quick-growing plantation, fruit, tea, vegetable, lotus roots, and flowers, etc. which try its best to intercropping planting. The livestock and poultry include cow, beef cattle, sheep, pig, fowl, duck, goose, etc. It also helps to promote high efficient animal and plant breed and integrated agriculture technique and feeding technique.

The model is an organic combination of ecological environment construction, green energy obtaining and organic agriculture production forming a household farm system with high economic and environmental protection efficiency and benign circulation on the base of Chinese rural household joint contract regime.
3.3.5 Project investment

The total estimated investment is 2,903,038 thousand RMB composed of 100,328 thousand RMB loan from world bank, 39,163 thousand RMB from national counterpart fund, local counterpart fund 42,969.5 thousand RMB and 105,874 thousand RMB contribution of farmer households.

The project investment of every province is shown in table 3-4.

<table>
<thead>
<tr>
<th>Province</th>
<th>Total (ten thousand RMB)</th>
<th>World bank loan (USD:RMB=1:7.7)</th>
<th>National counterpart fund</th>
<th>Local counterpart fund</th>
<th>Contribution of farmer households</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anhui</td>
<td>50412.5</td>
<td>19250</td>
<td>7424</td>
<td>13207.6</td>
<td>10530.8</td>
</tr>
<tr>
<td>Chongqing</td>
<td>44168.32</td>
<td>17710</td>
<td>7500</td>
<td>6100</td>
<td>12858.32</td>
</tr>
<tr>
<td>Guangxi</td>
<td>55724.1</td>
<td>21560</td>
<td>8085</td>
<td>11808.9</td>
<td>14270.3</td>
</tr>
<tr>
<td>Hubei</td>
<td>69346.1</td>
<td>15400</td>
<td>7000</td>
<td>4500</td>
<td>42446.1</td>
</tr>
<tr>
<td>Hunan</td>
<td>46457.6</td>
<td>18480</td>
<td>7272.5</td>
<td>6050</td>
<td>14655.2</td>
</tr>
<tr>
<td>Total</td>
<td>26608.64</td>
<td>92400</td>
<td>37781.48</td>
<td>41666.49</td>
<td>94760.67</td>
</tr>
</tbody>
</table>
4 BIOPHYSICAL AND SOCIO-ECONOMIC ENVIRONMENT

4.1 Biophysical Environment

4.1.1 Anhui Province

The land form of the project area is very complicated, including mountain, hill, ridge and plain, as well as extensive water surface and adequate water resource. The first great river Changjiang River and the third river Huai River cross it from west to east, and Chao Lake, one of the five greatest fresh lake and many other lakes are distributed in the project area.

Anhui Province is in the transition belt of temperate humid and subtropical zone. Climate is warm and humid and has distinct four seasons. North to the Huai River is sub humid monsoonal climate of temperate humid zone and south to the Huai River is subtropical humid monsoonal climate. The mean annual temperature is between 14 to 17°C the mean sunshine is 1800 to 2500 hours, the mean frost-free season is 200 to 250 days and the mean annual rainfall is 800 to 1800 mm.

4.1.2 Chongqing City

The project area is along the Changjiang River and Jialingjiang River, in the Pingxingling Valley hilly country of east Shchuang Province. The absolute altitude is 200-600 meters above mean sea level (amsl). The area is mainly Jurassic System purple shale and the soil is mainly purple soil and yellow soil with high fertility. The soil is loose and has good fertility. The land area is 29792 square kilometers, of which 1009.76 square kilometers is farmland. Changjiang River, Jialingjiang River and many rivers is in the area. The impoundage of the reservoirs and valleys is 876,700 cubic meters. The area has good canals and dams, adequate water resource and good farm and water conservation.

The area is subtropical humid monsoonal climate. The mean annual temperature is about 18°C. The winter lowest mean temperature is between 6-8°C and the summer mean temperature is between 27-29°C. The mean sunshine is 1000-1200 hours. Here has warm winter and hot summer, long frost-free season and adequate rainfall. The climate is humid and cloudy and the rainfall and the high mean temperatures always come together. Average annual rainfall is 1000-1400 mm. and most rainfall during summer and spring months occur during the night.

4.1.3 Guangxi Zhuang Autonomous Region

Guangxi project range is in the upstream of Zhujiang River system. The geographic coordinate is north latitude 21°31' to 26°C and east longitude 107°28' to 111°C. The total land area of the site is 172079 hectares of which 21.49% is farm and 25% is forest. The problem of soil erosion has been improved after ecological protection.
policies were carried out by local government.

The project area is located in south Asia tropic and middle subtropical monsoon climate. It is warm, sunny with high rainfall. The annual mean rainfall is 1300 to 2882 mm and the rainy season is concentrated during May to September when more than 80% of the annual rainfall events occur. The micro-climatic condition varies significantly due to the difference in altitude, aspects, etc. The annual mean temperature is 16 to 23°C, with the hottest month mean temperature of 26°C in August and the coldest month mean temperature of 10°C in January. The annual sunshine is 1307 to 1815 hours with annual radiant quantity 89.5 to 140.6 kilocalorie/cm². The frost-free season in normal year is 300 to 365 days. There are little natural or climate casualties in the range which are mainly spring or autumn drought, summer flood, hail and autumn clod, etc.

Guangxi province is at the southeast edge of Yungui Plateau, being more hills with a few plains. The surface relief is sloping from northwest to southeast, surrounded by hills and showing basin shape. There are many breakups of the basin edge and the centre and south portion is mainly plain. In the total land area, 39.8% is mountains region (above 400 meters altitude), 19.7% is tor (above 400 meters altitude), 10.3% is hill (within 200-400 meters altitude), 6.3% is highland (under 200 meters altitude), 20.6% is plain and 3.35% is water surface. The existing farm is about 40,000 Mu, which is about 11% of the total land area. Per capital farm is 0.82 Mu.

4.1.4 Hubei province

The project area of Hubei province lives in Enshi autonomous prefecture which belongs to the southwest mountainous region. The area is the national key supporting minority autonomous area and the only area being included in the western expansion. The total area is 24 thousand square kilometers with 262.1 thousand hectare of which 189.77 thousand hectare is dry land and 72.34 thousand square meters is water irrigated field.

The area is made up of three mountain systems which are Wu Mountain, Wuling Mountain, and Dalou Mountain. The highest areas live in the north, north west, and south east. The lowest area lives in the middle. The area is divided into five grades, whose altitude is 2000-1700m, 1500-1300m, 1200-1000m, 900-800m, 700-500m respectively.

The area is in the subtropical monsoonal climatic region, long frost-free season and adequate rainfall. The annual temperature is 15 to 27°C, with the hottest month temperature of 27°C in July and the coldest month temperature of 3°C in January. The mean sunshine is 1100-1400 hours. Average annual rainfall is 1400-1600 mm.

4.1.5 Hunan Province

Hunan is between east longitudes 108°47’ to 114°15’ and north latitude 24°38’ to 30°08’. It is adjacent to Mountain Mufu, Mountain Wugong and Jiangxi Province on the east, adjacent to Yungui plateau on the west, adjacent to Chongqing at Mountain
Wuling on the northwest, adjacent to Guangdong Province and Guangxi Province at Mountain Nanling and adjacent to Hubei Province at Binhu Plain. The total area is 211.875 square kilometers which is the 10th in China.

Hunan is surrounded by mountains on the east, south and west, with Mountain Mufu and Mountain Luoxiao on the east, Mountain Wuling and Mountain Xuefeng on the west and Mountain Wuling on the south. Hills, valleys and basins are alternate in the midland. There are four great hydrographical systems in the area of Xiang, Zi, Yuan and Li Rivers. The area is high on the south and low on the north and sloping to midland and north part, which shows U-shape. There are four soil types of red earth, yellow earth, yellow brown earth and mountain meadow-steppe soil. The red earth occupies the largest area of half of the total province area. The soil derived from farming is divided into red limestone soil, purple soil, moisture soil and rice soil, etc. Of which the rice soil occupies 16.5% of the total soil area and is the main production base of grain, cotton and oil.

Hunan province is in the subtropical monsoonal humid climatic province. The area is warm and has distinct seasons, high rainfall and adequate sunshine. The annual mean temperature is about 16 to 18°C. The days with temperature above 10°C are 240 to 260 days. The frost-free period is about 265-310 days. The annual mean rainfall is 1300 to 1600 mm, included as one of the provinces with adequate rainfall in China.

4.2 Socio-economic Environment

4.2.1 Anhui Province

Anhui Province has 18 project counties which include 157 towns, 2108 villages and total 8346 thousand population, of which 7158 thousand is agriculture population. There are 1920 thousand households. The area is 76240 thousand hectares.

The agriculture production of the project area has prominent regional features. Taking the Huaihe River as a division line, the north to Huaihe River engages mainly in dry crops cultivation, while the south to Huaihe River in paddy rice growing. Major crops in the northern Haihe River plain include wheat, potato, bean, maize, cotton, peanut, sesame and hemp; and livestock farming covers mainly cattle, pig, sheep, chicken and rabbit; In Yangtze Huaihe hilly country, farmers mainly grow paddy rice, wheat, potato, cotton, cole, peanut, hemp etc, and raise pig, fowl, cattle and sheep; along the river plains, paddy rice, cole, cotton are major crops, and pig, water fowl the major livestock; Southern Anhui Province and Dabieshan Mountain are the area for rice, cole, maize, potato cash crops and livestock like pig, cattle and fowl.

4.2.2 Chongqing City

The project area of Chongqing Municipality covers 50 townships in 12 districts (counties, cities). The total project area is 29,794 km². And it involves 75000 households in 296 villages, of which, 1000 households are poor households.
In 2005, at the total 12 project districts (cities, counties), the output of grain, oil crop, vegetable, and fruit reached 4.82 million tons, 0.12 million tons, 2.983 million tons and 4.234 million tons respectively. Total pig, cattle and sheep supplied to the market reached 9.817 million heads, 239,400 heads, and 890,500 heads respectively. Total meat production was 784,0000tons; aquatic product reached 112,000 tons. Many industries with local advantages including quality medicinal herb, flower seedling, export-oriented quality orange, pig etc. have formed. The production value of township enterprises was increased by 14.578 billion RMB Yuan.

4.2.3 Guangxi Zhuang Autonomous Region

In the 8 project counties (districts), there are 1054.098 thousand households, 65,584biogas digesters with a possessing rate among all households of 28.0%. The project plans to construct 80850 biogas digesters. There are 4533.077 thousand populations in the project area.

In 2005, the average income of project area is 2415 yuan per capital. The most contribute to local economic came from planting and breeding. The total output value of planting and breeding is 1392 million yuan, 436 million yuan. The area of rice, vegetable, and fruit is 46816 ha, 9481 ha, 12103ha respectively. The output of rice, vegetable, and fruit reached 217 thousand tons, 298 thousand tons, 246 thousand tons respectively. The number of pig, cattle and chicken supplied to the market is 387 thousand, 63 thousands, and 188 thousand respectively.

4.2.4 Hubei Province

The total area of Enshi is 24,000km², of which arable land is 262,100ha (involving dry land of 189,770ha and paddy field of 72,340ha). It governs 6countied, 2cities; 88townships (sub district offices), 2476vileges with a total population of 3,810,100 (involving rural households of 925,200 and rural population of 332,990). In 2005, the GDP of Enshi was 17.3billion RMB with 4912RMB per capita. The total output value of agriculture, forestry, animal husbandry and fishery was 10.848billion RMB, of which, the total output value of agriculture, forestry, animal husbandry and fishery was 6.572 billion RMB, 0.308 billion RMB,3.862 billion RMB and 0.038 billion RMB respectively. The total growing area of grain and vegetable was 406,500ha and 84,820ha respectively. The amount of live pigs, sheep and poultry selling to the market was 3,298,500heads, 349,800heads and 5,592,600heads respectively. The total output of livestock, poultry and meat was 297,900tons, of which pock output was 278,000tons.

4.2.5 Hunan Province

The project area in Hunan includes 10cities (prefectures), 18counties (cities), with a total area of 309,000,000km² (involving arable land of 689,490ha, of which paddy
field and dry land is 571,090ha and 113,090ha respectively) and population of 12,152,000 (involving agricultural population of 10,220,000 and households of 3,079,000).

In 2005, the total grain sowing area is 1,094,700ha, with a total output of 6,953,000 tons. Specific breakdowns are as follows: (1) Rice sowing area: 896,120ha; output: 5,958,400 tons; (2) Oil crop sowing area: 130,300ha; output: 210,900 tons; (3) Vegetable sowing area: 197,900 ha; output: 5,625,000 tons; (4) Fruit output is 744,500 tons, of which, orange sowing area is 94,630ha and output is 331,800 tons; (5) Annual supply of pig: 16.7986 million heads; amount of cattle on hand: 867,1000 heads; (6) Aquaculture. Acreage: 95,150ha; output: 271,900 tons. In 2005, the total output value of agriculture, forestry, animal husbandry, and fishery reached 38.399 billion RMB, and farmer income per capita was 2,855.7 RMB.
5 PUBLIC CONSULTATIONS

In order to respond to the relevant requirements of the National Environmental Protection Agency, the World Bank and the environment impact appraisal technology guidance, extensive information about the Eco-Farming Project was issued in the project areas and detailed public consultation was carried out to solicit public opinions and to provide a good basis for the project implementation, and management, based on the provided public input.

5.1 Public participation mode and content

5.1.1 Information disclosure

According to the requirements of public participation of the National Environmental Protection Agency and the World Bank, at every stage of the environmental impact assessment, the evaluation contents of the project and environmental impact assessment is issued to the public from time to time to keep the public feedback channel free, at the same time, adjust work content according to feedback result. The process of the project information disclosure was as following:

(1) At the early stages of the environmental impact assessment work, the project information on was publicized in provincial medium in the project areas (Hubei, Hunan, Anhui, Guangxi and Chongqing). The main project content was introduced, contacts were made with the related development organization and environmental organizations, and the proposed environmental impact assessment outline was provided for comments. The perceived potential positive and negative impacts of the project on environment were presented, and opinions and advice of general public, relevant government and non-government organization were solicited.

(2) At the later stage of environmental impact assessment work, the draft environmental impact assessment report was publicized on the project area media and comments were solicited on the report to further collect the public opinions and modify report according to their feedbacks and suggestions.

5.1.2 Meeting

A number of meetings were arranged in every province and county to discuss the potential environmental impacts of the project. Relevant government department principals, technical personnel, farmers, industrial association, People's Congress, Political Consultative Conference and Women Association were invited to attend. The main meeting contents were: project introduction, the possible positive and negative influence to environment caused by the project, the environmental problems that should be emphasized at the preparation and implementation period of the project, the public understanding degree and attitude to the project and opinions and suggestions to the project environmental impact assessment.
5.1.3 Farmer interview

The main objectives of the interview with farmers in the project area were to find out the general attitude and concerns of both farmers that are participating in the project (beneficiaries) and those who are not participating in the project (non-beneficiaries). The main purpose was to better understand the actual production and living characters of the project areas, the farmers' household situations, including population, labor force, pocketbook, income, expenditure level and energy structure, as well as the local residents' opinions, idea, expectations and requirements/expectations from the project.

5.1.4 Questionnaire investigation

A Questionnaire was issued to Public Participants (Table 5-1) regarding the proposed project was distributed in project counties to collect the ideas and suggestions of as large a group of people from different ways of life as possible. In general, a total of 200 sample persons were randomly selected in every province.

The public investigation was conducted using random sampling to collect more representative results. Random sample allows for a better definition of project characteristics and provide a higher probability of including informants from different social strata in the project area. The participants included project beneficiaries, non-beneficiaries, Han nationality, minorities, different age and gender groups, as well as people from different ways of life and professions.

<table>
<thead>
<tr>
<th>Table 5-1 Questionnaire of public participant</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investigation items</strong></td>
</tr>
<tr>
<td>Name:</td>
</tr>
<tr>
<td>Option</td>
</tr>
<tr>
<td>1. Are you satisfied with the present local economy and environmental condition?</td>
</tr>
<tr>
<td>2. Do you think it is necessary to build this project?</td>
</tr>
<tr>
<td>3. What is your main fuel source</td>
</tr>
<tr>
<td>4. What is the most sensitive environmental issue in project area?</td>
</tr>
<tr>
<td>5. Which period do you think the project might have negative impact on the environment?</td>
</tr>
<tr>
<td>6. What influence do you think the project will bring to local environment?</td>
</tr>
<tr>
<td>7. What impact the project will have on residents' standard of living and health conditions?</td>
</tr>
</tbody>
</table>
9. Do you think the project will increase farmers income?  
<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
<th>Not significantly</th>
</tr>
</thead>
</table>

10. After detailed study, will you support the project?  
<table>
<thead>
<tr>
<th>Yes</th>
<th>Indifferent</th>
<th>No</th>
</tr>
</thead>
</table>

11. Other opinions and suggestions

5.2 Result analysis

5.2.1 Information disclosure

All project provinces have issued the construction information, development organization, environmental impact assessment organization and environmental impact assessment outline on the province web site before September 30th. The detailed network address is as following:

Table 5-2 Network address of every province

<table>
<thead>
<tr>
<th>Province</th>
<th>Network address</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chongqing</td>
<td><a href="http://www.cqagri.gov.cn/zw/detail.asp?pubID=210887">http://www.cqagri.gov.cn/zw/detail.asp?pubID=210887</a></td>
</tr>
<tr>
<td>Hunan</td>
<td><a href="http://www.hnagri.gov.cn/tztg/read_xx.asp?id=179">http://www.hnagri.gov.cn/tztg/read_xx.asp?id=179</a></td>
</tr>
</tbody>
</table>

According to the requirements of the World Bank, the environmental impact assessment outline should stay on the network at least for 3 weeks until October 25th.

5.2.2 Farmer interviews

The environmental assessment team visited the project sites during September and October, 2006. The investigation scope included visits and discussions with farmers who have established biogas digesters and those who have not in order to collect their opinions with regard to the impact and usefulness of the proposed Eco-Farming project. The main findings include:

(1) There should be a training/awareness course for the farmers in the project area who are not well aware of the benefits of Eco-Farming Project so that they can actively participate in the project

(2) Most farmers were found to be enthusiastic to participate in the project and hope that government can start the project as soon as possible.

(3) It is the general belief that the Eco-Farming Project can effectively improve the sanitation conditions of farmer family households. Use of biogas as a clean source of energy is believed to allow for reduction in the need to pile firewood in the courtyard. It is believed that most farmers will be accustomed to cleaning and adding the feces
of the poultry and livestock into the biogas digester, improving the sanitation condition of the barn and reducing the population of flies and mosquitoes in the kitchen and courtyard. Use of biogas stove instead of fuel wood stove will reduce smoke and clean the kitchen, allowing for better sanitation conditions for the whole family and reduce sick days and medicine cost.

(4) The rural production material price is rising, especially the price of fertilizers and pesticides, increasing the cost of agriculture production. Use of biogas liquid and biogas residue as a high quality organic fertilizer as a substitute for chemical fertilizers should reduce cost of agricultural production and increase farmers' income.

(5) Production of biogas liquid and residue will promote the development of green food and organic industry that should increase farmers' income.

(6) Use of biogas should reduce the need for firewood that is mainly sourced from nearby forests, reducing the impact on the ecological environment.

(7) In some project areas, support technology is not fully available to the farmers. Farmers hope that the project will allow for a better dissemination and availability of relevant support technology during both construction and operation of the biogas digesters. The existing support for biogas technology should be strengthened and the number of qualified experts and technical staff should be increased.

5.2.3 Meeting

Project meetings on the environmental impact of the Eco-Farming Project were hold in Anhui, Chongqing, Guangxi, Hubei and Hunan respectively between October 9th and 19th, 2006. Non-government organization and relevant government organization, as well as interested people were invited to attend. The minutes of the meetings are included in Attachment.

The meetings in five provinces achieved the following main conclusions:

1. It is firmly believed that the Eco-Farming project will improve the peasants' economic and living conditions. Farmers in the project area have seen and felt the benefits of biogas system and are enthusiastic to join the project.

2. In areas were biogas system has already installed, the ecological environment has already improved and the percent of forest cover has increased. Some farmlands have been turned back to forest and soil and water erosion rates are reduced, indicating the positive impact of the project on natural environment.

3. The rural women benefit most from the project though saving in time for cooking and fuel wood gathering. The work conditions are also improved. Some of the women, having more free time, have started to train in other skills to increase their income that should improve their social position.

4. Since the number of farmers who are willing to join the project is rapidly increasing, there is a urgent need to improve and strengthen the management and
service skills of the project team members, especially the management and technological service team to ensure and promote the successful implementation of the project.

5.2.4 Questionnaire result

In total, 1000 questionnaires were distributed in the five provinces. A total of 982 questionnaires were returned (98.2%). A summary of the investigation results are presented in table 5.3.

According to the statistical analysis of the investigation results, most farmers investigated have some understanding of the project. The main energy source in the study area appears to be paddy stem and firewood. Most farmers believe the project will improve their living conditions and health level, increase their income, improve the local ecological environment, and promote local economic development. They believe it is a good idea and necessary to implement the project and show great support for the project. As for the opinions and suggestions about the project, some farmer who can’t participate in the project hope that the project scope can be broadened to accept more farmers, some farmers hopes to improve local irrigating and drinking conditions and strengthen technological guidance, training and services for the farmers.

<table>
<thead>
<tr>
<th>Investigation items</th>
<th>Option</th>
<th>Percent</th>
<th>Investigation items</th>
<th>Option</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Are you satisfied with the present local economy and environmental condition?</td>
<td>Satisfied</td>
<td>33</td>
<td>2. Do you think it is necessary to build this project?</td>
<td>Yes</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Partly satisfied</td>
<td>51</td>
<td></td>
<td>No</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Not satisfied</td>
<td>16</td>
<td></td>
<td>No comment</td>
<td>3</td>
</tr>
<tr>
<td>3. What is your main fuel source</td>
<td>Coal</td>
<td>27</td>
<td>4. What is the most sensitive environmental issue in project area:</td>
<td>Aquatic</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Firewood</td>
<td>20</td>
<td></td>
<td>Atmospheric</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Paddy straw</td>
<td>51</td>
<td></td>
<td>Acoustic</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Others</td>
<td>2</td>
<td></td>
<td>Ecologic</td>
<td>43</td>
</tr>
<tr>
<td>5. Which period do you think the project might have negative impact on the environment:</td>
<td>Construction</td>
<td>37</td>
<td>6. What influence do you think the project will bring to local environment?</td>
<td>Positive</td>
<td>93</td>
</tr>
<tr>
<td></td>
<td>Operation</td>
<td>6</td>
<td></td>
<td>Negative</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Both</td>
<td>12</td>
<td></td>
<td>Both</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>45</td>
<td></td>
<td>Unknown</td>
<td>5</td>
</tr>
<tr>
<td>7. What impact the project will have on residents' standard of living and health conditions?</td>
<td>Improve</td>
<td>99</td>
<td>8. Do you think the project will improve local socio-economic condition?</td>
<td>Yes</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>No impact</td>
<td>1</td>
<td></td>
<td>Not significantly</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Worsen</td>
<td>0</td>
<td></td>
<td>No</td>
<td>1</td>
</tr>
<tr>
<td>9. Do you think the project will increase</td>
<td>Yes</td>
<td>96</td>
<td>10. After detailed study, will you</td>
<td>Yes</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0</td>
<td></td>
<td>Indifferent</td>
<td>3</td>
</tr>
<tr>
<td>farmers income?</td>
<td>Not significantly</td>
<td>support the project?</td>
<td>No</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>-------------------</td>
<td>----------------------</td>
<td>----</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>11. Other opinions and suggestions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6 POTENTIAL IMPACTS OF ECO-FARMING PROJECTS

The main potential negative impact of the project is believed to be short term in nature and reversible. The main potential impacts include:

(1) During the construction of the biogas digester, an area of some 8 to 10 m³ need to be excavated to build the biogas digester, causing some minor noise and solid waste (spoiled soil).

(2) Some counties will build village roads that can possibly damage some roadside vegetation and cause minor volume of dust, noise and solid waste.

Since the scale of such construction is small, the potential environmental impact is minimal, short-term and reversible. Strengthen the environmental administration measures so the negative effect will vanish following with the complement of the construction.

In general most of the long-term environmental impacts of the proposed project during operation are believed to be positive. According to the relevant project experience in other locations within the project provinces and elsewhere in China, the project operation may have some potential environmental risks that are further discussed in this chapter.

6.1 Potential impacts at household level

Each farmer family who join the project must construct the biogas digester, modify washroom, kitchen and barn as a minimum. The family should transfer the livestock, poultry and night soil waste into the biogas digester to reduce waste and develop biogas energy. In addition, he should use the treated bio-liquid and bio-solids as organic fertilizer in agricultural production, reducing the need for agricultural chemicals and to improve their living and production conditions. The main positive environmental impacts of the project during operation phase include:

6.1.1 Change the energy structure of the farmer

Traditionally, the main sources of energy in the project areas are firewood, paddy straw and coal. Those areas with better economic conditions also use some liquid gas and electricity, but the cooking, making pig feed and most of the heating are still mainly using firewood and coal (different districts use different dominant energy sources). Most ordinary farmer households, a family of four, use about 2000 kilograms of firewood and 1000 kilogram of coal annually.

Table 6.1 present the data provided by the Biogas Institute of MOA regarding the capacity of biogas to replace other sources of fuels. According to the data provided by the institute, after establishing biogas digesters, produced biogas can meet the cooking energy of farmers for about 8 to 10 months per year, reducing some 75% of the traditional energy requirements. According to the available statistics, an 8 m³ biogas digester can produce about 385 m³ of biogas, about 1.05 m³ every day and a 10 m³ biogas digester can produce 450 m³ biogas, about 1.26 m³ every day that can
generally satisfy the to cooking, bathing and preparing pig feed requirements of an ordinary family. (These technical numbers are provided by Ms. Hao Xianrong, who works in China Biogas Research Institute as a technician.)

Table 6-1 Substitute energy list of the biogas

<table>
<thead>
<tr>
<th>Energy type</th>
<th>1 m³ biogas digester</th>
<th>8 m³ biogas digester</th>
<th>10 m³ biogas digester</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard coal</td>
<td>0.714kg</td>
<td>275kg</td>
<td>321kg</td>
</tr>
<tr>
<td>Paddy straw</td>
<td>4.23kg</td>
<td>1630kg</td>
<td>1903kg</td>
</tr>
<tr>
<td>Firewood</td>
<td>3.13kg</td>
<td>1204kg</td>
<td>1408kg</td>
</tr>
<tr>
<td>coal</td>
<td>2.2 kg</td>
<td>847kg</td>
<td>990 kg</td>
</tr>
</tbody>
</table>

(Provided by Ms. Hao Xianrong)

It can be concluded from the data presented in Table 6.1 that an 8 m³ biogas digester can save 1204 kilogram of firewood (2288 kilogram wet firewood) or 847 kilogram of coal. A 10 m³ biogas digester can save some 1408 kilogram of firewood (2816 kilogram wet firewood) or 990 kilogram of coal.

6.1.2 Reduction in greenhouse gas emissions

(1) Energy substitution will reduce greenhouse gas emissions

Using the Global Climate Change and Greenhouse Gas List Program Method, CO₂ emission factor of civil coal is 1.517 tons of CO₂/t, the CH₄ emission factor of firewood lighting is 0.00496 tons of CH₄/t and the CH₄ emission factor of paddy stem is 0.00243 tons of CH₄e

Table 6-2 Reduction in volume of greenhouse gas emissions due to use of biogas

<table>
<thead>
<tr>
<th>Energy type</th>
<th>Substituted volume</th>
<th>CO₂</th>
<th>CH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td>8 m³ biogas digester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy straw</td>
<td>1630 kg</td>
<td></td>
<td>4.0 kg</td>
</tr>
<tr>
<td>Firewood</td>
<td>1204 kg</td>
<td></td>
<td>6.0 kg</td>
</tr>
<tr>
<td>Coal</td>
<td>847 kg</td>
<td>1285kg</td>
<td>—</td>
</tr>
<tr>
<td>10 m³ biogas digester</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy straw</td>
<td>1903kg</td>
<td></td>
<td>4.6 kg</td>
</tr>
<tr>
<td>Firewood</td>
<td>1408 kg</td>
<td></td>
<td>7.0 kg</td>
</tr>
<tr>
<td>Coal</td>
<td>990 kg</td>
<td>1501kg</td>
<td>—</td>
</tr>
</tbody>
</table>

(Cited from Wang Jiuchen, 2003)

(2) Timely utilization of livestock and poultry manure and reduction of greenhouse gas emission

Fermentation of livestock and poultry waste occurs in the biogas digester through their anaerobic decomposition, producing biogas. In the absence of biogas digester system, the animal manure, is usually piled for a long time in the farmyard to aerobically decompose before field application, causing emission of CH₄ to the atmosphere.

For example pig manure, the calculation data according to IPCC, the CH₄ emission
factor under the piled conditions is 2.09, while 4.18 under biogas fermentation. Since the project area is very large and different models are used by different farmer communities, it is very difficult to provide a detailed calculation of greenhouse gases produced by the project by source. To simplify the process, it is assumed that every family has 3 pigs. If the pig manure is not utilized in a biogas (present condition) \( \text{CH}_4 \) emission volume will be in the order of some 6.27 kg per family, entering directly into atmosphere without being utilized. However, if the manure is collected and fermented in the biogas digester, biogas can be produced as an energy source, replacing the use of additional firewood/straw/coal that can increase the green house gas emission by the amount that would have been lost to the air by the aerobic fermentation of pile manure (6.27 kg per family).

(3) Impact on air pollution

Using biogas as a clean energy source to replace traditional energy sources should reduce \( \text{SO}_x \) and particulate matter, reducing air pollution.

Assuming that coal contains 1% sulfur and 20% ash, a family with an 8 m\(^3\) biogas digester will save 0.847 tons of coal per year, reducing 16.9 kg of \( \text{SO}_x \) emission and 169 kg of particulate matter, while a 10m\(^3\) biogas digester will reduce 19.8 kg \( \text{SO}_x \) emission and 198 kg of particulate matter.

6.1.3 Impact on forest protection

Use of biogas for energy production should reduce firewood consumption by project beneficiaries that should effectively protect forests, increasing the capacity of the forest as a carbon sink. According to the investigation of the 86 demonstration villages by the country economy research center, the MoA's Eco-farming Enriching Peasant Project, a biogas digester will save in average 1.2 tons of firewood (with 5% water), equaling to 2.2 tons of wet firewood, compared to the national average levels. If every Mu of forest equals to 700 kg of wet firewood, every biogas digester will protect some 3.3 Mu of forest (equals to 0.22 ha).

6.1.4 Biogas residue impacts

Biogas fertilizer is the residue of the farmyard manure and night soil after anaerobic fermentation, which includes biogas liquid and solids with high concentration of organic ashes, humid acids, amino acids, N, P, K and micronutrients that are mostly required for plant growth. The biogas residue has high concentration of macro- and micro-nutrients and can be used for basal fertilizer application, side-dressing, topdressing, and as the nutrient source during incubation period for mushroom grow ups. Biogas residue, due to high percentage of organic matter, can have a significant positive impact on soil structure, aeration, as well as chemical properties, by increasing soil fertility, avoiding insect pests, thus assisting the increase in crop yield.

(1) Impact on soil and ground water pollution
Farmers in the project areas have the habit of breeding livestock and applying the farmyard manure directly to the soil without adequate fermentation. There is high potential soil and plant contamination due to the presence of high concentration of harmful germs and parasites in the untreated farmyard manure. The applied untreated farmyard manure also produces a noxious odor that can have negative impact on the nearby communities. The water used for cleaning the barnyard is generally discharged directly to the environment, causing pollution of nearby surface and ground water resources.

Use of farmyard manure and night soil for biogas production and allowance for adequate anaerobic fermentation of the manure in the tank should significantly reduce microbiological and parasitic harmfulness of the biogas slurries, thus reducing the negative impact of manure application on public health within the area, for the downstream water users, and people who use groundwater in nearby communities. In addition, the anaerobic treatment of the farmyard manure will significantly reduce odor pollution in surrounding areas.

(2) Impact on fertilizer use

The amount of macro- and micro-nutrients in biogas slurries is almost similar to the amount in the untreated farmyard manure. Table 6.3 presents the average nutrient content of biogas slurries.

<table>
<thead>
<tr>
<th>Item</th>
<th>Nutrition content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biogas liquid</td>
<td>N: 0.03 % to 0.08 %, P: 0.02 % to 0.03 %, K: 0.05 % to 0.07 %; mineral substance (such as Ca, Mg, Cu, Fe, Zn, Mn, etc.), 8 amino acids, cold resistance substance (such as praline, linoleic acid and yellow acid, etc.), growth stimulant (such as abscisin, auxin and gibberelin, etc.) vitamin B and some antibiotic.</td>
</tr>
<tr>
<td>Biogas solids</td>
<td>Organic material 36.0 % to 49.9 %, humid acid 10.1 % to 24.6 %, coarse protein 5.0 % to 9.0 %, N 0.78 % to 1.61 %, P 0.4 % to 0.6 %, and K 0.61 % to 1.30 %</td>
</tr>
</tbody>
</table>

(Provided by Ms. Hao Xianrong)

The main fertilizer used by the farmer is farmyard manure and chemical fertilizer. The main nutrient source used by the farmers in the project area is the farmyard manure and night soil that are both carrying a comprehensive dose of different nutrients and minerals that are required for plant growth and soil structural development. The average recovery rate of different macro-nutrients in manure is estimated at above 90% for nitrogen and almost 100% for P and K. The effective P occupies 20% of the total P content in farmyard manure. Chemical fertilizers used by the farmers are single element fertilizer. The nutrient release quickly and is readily available to the plant. However, rapid availability can also allow for quicker loss, either by runoff (P fertilizer) to water resources or leach (mainly N fertilizer) to
the groundwater and/or as nitrous oxides to the atmosphere. The nutrient content of farmyard manure and major fertilizers used in project area are provided in Table 6.4.

<table>
<thead>
<tr>
<th>Fertilizer type</th>
<th>N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmyard manure</td>
<td>4.70</td>
<td>0.79</td>
<td>3.03</td>
</tr>
<tr>
<td>Biogas residue</td>
<td>6.35</td>
<td>1.09</td>
<td>4.64</td>
</tr>
<tr>
<td>Urea</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>triple superphosphate (P₂O₅)</td>
<td></td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Muriate of potash (KCl)</td>
<td></td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

(Provided by Ms. Hao Xianrong)

In average, each biogas digester produces 8355 kg of biogas liquid, and 4245 kg of biogas solids residue, totaling some 12600 kg. Using the nutritional characteristics of biogas residue in Table 6.4, biogas residue from a biogas digester contains 50.46 kg of N, 8.69 kg of P and 37 kg of K that is equals to 110 kg of urea, 19 kg of triple superphosphate and 61.7 kg of muriate of potash.

(3) Impact on farmer crop production and breeding income

Biogas residue is a good quality organic fertilizer and can be widely used in different agricultural production systems. Considering the cost of chemical fertilizers, the use of biogas residues as fertilizer should assist farmers to have a better financial returns from their production system. Table 6-5 presents the potential benefits of using biogas residue as organic soil amendment in various agriculture models.

<table>
<thead>
<tr>
<th>Item</th>
<th>Account</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pig breeding using biogas liquid</td>
<td>One per family</td>
<td>Good appetite, bright hair color, love quiet and sleep. Average daily weight increase of some 10.2%. Shorten breeding period of 11 days, saving 34.6 kg feed.</td>
</tr>
<tr>
<td>Fruit tree planting, using biogas residue</td>
<td>667 m² per family</td>
<td>1.2% increase in unit area of fertile fruit crops and an average output increase of 22.7%. Earlier fruit maturity. Bright color, good taste and high sugar content.</td>
</tr>
<tr>
<td>Growing vegetables, using biogas residue</td>
<td>667 m² per family</td>
<td>Average production increase of 28.4%. Early crop maturity. Vegetable is generally greener and has brighter leaves. Fewer insect pests.</td>
</tr>
<tr>
<td>Breeding fish, using biogas residue</td>
<td>667 m² per family</td>
<td>Average production increase by 2536%. Reduction in disease incidents. Fish produces a better color. Presence of more planktons and oxygen in the water.</td>
</tr>
<tr>
<td>Growing cotton using biogas residue</td>
<td>667 m² per family</td>
<td>Higher emergence rate. Less incidents of diseases. Cotton stem becomes taller and thicker. Increase yield by an average of 20.69% per Mu.</td>
</tr>
</tbody>
</table>
6.1.5 Impact on pesticide use

Farmers in the project area generally use pesticide during crop growth with an average use of 7 to 8 kg/ha. The type and amount of pesticide used varies greatly in different areas and for different crops.

Available research data indicate that the anaerobic fermentation residue has a significant impact on prevention and cure of the effect of some 23 diseases and 15 pests in 11 types of crops, food, industrial vegetable and fruit. Application of biogas slurries greatly reduces the dosage of chemical fertilizers and pesticides, causing a significant reduction in pollution of terrestrial and aquatic environment.

The insecticidal and disease prevention effect of biogas residue is very close to most pesticides. The mechanism is believed to be:

- It directly control or destroy the source of plant diseases;
- Protect the plant from diseases and pest damage; and
- Promote plant growth by increasing its disease and pest resistance.

It is believed by the scientific community that biogas residue has both acting as a nutrient source (fertilizer) and a comprehensive “biologic pesticide” and, contrary to agrochemicals, does not produce drug resistance in the agricultural crops or pollute the natural environment.

Use of biogas residue allows the local farmers to join in green food production by abandoning the use of pesticides. Even those farmers who do not want to grow green food can reduce their use of pesticides by over 30%, reducing their cost of production.

6.1.6 Impact on the family sanitary environment

Livestock breeding/raising is generally practiced in the project areas. Every family has several domestic animals (mainly pigs, cows, and poultry). The traditional system is based on piling the farmyard manure from livestock and poultry in the farmyard, developing a suitable environment for mosquito and fly breeding and a strong and unpleasant odor, causing a very poor sanitation condition.

The main fuel sources within project area are firewood, straw, and coal. Use of electricity and liquid gas is seldom practiced in the project area. Every family uses a large amount of firewood and coal, which is generally piled in the farmyard, forming poor sanitary environment.

Most kitchens in the project area are using firewood hearth. During cooking, firewood does not completely burn, producing a lot of smoke and noxious gases.
Smoke makes both kitchenware and house smoky.

Installation of biogas digester will allow farmyard manure and night soil to directly enter the biogas digester, helping farming families to have a better sanitary condition in the house and the barnyard.

Use of biogas as the energy source will allow the farmer to reduce his need for cutting firewood. Reduction in the need for collection of wet firewood that requires drying in firewood piles within the courtyard will reduce the volume of branches and sticks in the courtyard and provide more space for other uses. The biogas stove occupies less area than traditional stoves. In addition, biogas burns completely and does not produce smoke and noxious gases such as CO.

6.1.7 Impact on farmers health status

Traditionally, the main energy source used for cooking in the project area is firewood. Firewood does not normally burn completely and a large amount of smoke is produced, causing major eyes and respiratory system ailment, especially in women and children. Therefore, majority of women have a watery eyes and cough heavily during cooking. Working and living in such conditions for a long time causes an increase in eyes and respiratory system diseases, especially within women groups. Farmers in the project area are well aware of the impact of traditional stoves on health condition of the family and have a strong positive feeling about using the biogas system.

Use of biogas as the main source of energy should reduce the concentration of CO, SO₂ and smoke in the farming families environment, improving the families health status by reducing the incidents of eye and respiratory system diseases.

6.2 Environmental Impacts at village level

6.2.1 Impact on energy structure and greenhouse gas emission

(1) Energy substitute

After biogas digesters are constructed, they can generally satisfy the normal cooking, bathing and pig feed making requirement of the households and reduce the need for consumption of firewood, paddy straw and coal. Using the factors provided in Table 6.2, and assuming that every village has in average 400 families, 652 tons of paddies straw, 482 tons of firewood (964 tons of wet firewood) and 339 tons of coal can be saved every year.

(2) Impact on greenhouse gas emission, NOx and SOx

Use of biogas instead of coal and fuel wood should reduce the relative greenhouse gas emission of a village as follows:

Paddy straw substitution: CH₄ 1.6 t;
Firewood substitution: CH₄ 2.4 t;
Coal substitution: $\text{CO}_2$ 514 t, $\text{SO}_2$ 6.76 t, smoke 67.6 t.

6.2.2 Protecting forest resources

(1) Impact on forest harvesting as a fuel source

538,650 families involved in eco-farming should save, about 675,000 tons Firewood, significantly reduce forest cutting for fuelwood, keeping high percentage of forest cover intact.

(2) Impact on returning farm to forest

Parts of the project area are located in mountainous or hilly districts and suitable land for farming is limited. In order to increase income, many farmers reclaimed lands on terraces, with slope of more than 20°, which is very hard to plant and far away from the inhabiting sites. The Eco-Farming project should increase farmers’ income and improve their economic conditions. Farming income from better farmland, in addition to the breeding and other agricultural activities should increase their income, allowing them to return farmland on slopes to forest or grassland to increase forest cover of the mountainous and hilly areas and improve local ecological conditions.

6.2.3 Impact on village sanitation conditions

(1) Use of biogas digester will not only provide a source of heating energy, but it will also provide a treatment for farmyard manure and night soil. Biogas digester, through anaerobic digestion, treat the night soil and farmyard manure and reduces the pathogen concentration to safe levels as long as adequate digestion period is used. The process will reduce intestinal infectious diseases, parasitic diseases such as bacillus, coli flora, helminth ovum, and infectious hookworm.

Investigation conducted by the MoA in Hubei, Shanxi and Guizhou provinces demonstrated that biogas fermentation can prevent the incidence of infectious diseases that can affect both human and livestock. For example: in April of 2005, there was a large scale epidemic of streptococcal in pigs in Ziyang County, Sichuan Province. However, those families who used biogas digester were not affected.

Local experience has indicated that a digestion period of over three months in biogas digester is adequate to reduce parasite ovum levels to undetectable levels in the fermentation liquid that satisfies the national standard for biogas residue.

The incidence of parasitic diseases such as ascariasis, ancylostomiasis and gastroenteritis are respectively 2.90, 3.92 and 9.86 times higher in households without a biogas digester. Mosquito and flies also have a higher rates of appearance, as much as 2.03 times in houses without the biogas digester. In addition, the enterobiasis incidence was zero in families with biogas digester.

In general, the use of biogas system has significantly improved the health status of communities that are using the system.
Some counties implemented water supply projects after implementing the biogas digester project that has further improved the health status of the farming communities.

The proposed project should significantly improve the environmental sanitation within project areas that should assist in reaching the socialistic new country goals.

6.2.4 Impact on village production and living condition

Project implementation should improve farmers’ living condition and reduce the time spent on fuel wood collection, especially for the women, providing them more time for studying, entertainment and to take part in social activities. It should also allow for strengthening the communication between farmers.

The living condition and income levels within areas with high concentration of ethnic minorities should also improve significantly, if eco-farming project target such communities.

Construction and expansion of village roads should improve the village traffic conditions, facilitate farmers access to farmland and ease the transport of the produce to the market.

6.2.5 Impact on farmers technical proficiency

Agriculture technology training programs during the project implementation should improve farmer’s knowledge of agricultural production technology. Agriculture technology experts often provide guidance on new and appropriate technologies to farmers, allowing them to improve their agricultural activities. They will popularize the biogas technology, train biogas experts, and increase farmers’ awareness of methods to save energy and protect the natural environment.

6.3 Potential Environmental Risk

Review of the findings of previously implemented biogas projects identify a number of potentially significant environmental risks that such project may bring about if project proponents do not provide adequate attention to potential environmental risks and safety issues that are described below

Biogas is a flammable gas. If improperly used, it may burn or make person asphyxiate that put the properties and lives in danger;

There concentration of infectious diseases microbes in animal manure and night soil is very high. If adequate residents time is not allowed to effectively reduce the concentration of pathogens in the biogas digester, the concentration of pathogens might be too high during bio-slurry/bio-liquid application that can cause serious ailment in the farming communities who are in contact with the bio-slurry/bio-liquid or inhale the fumes; and

Biogas residue (mainly bio-liquid and bio-slurry) contains high concentration of
fertilizer. If over application of liquid/slurry is practiced by the local farmers, especially during the land preparation (basal application), high levels of nitrogen fertilizer can pollute the soil, surface, and groundwater and P-fertilizer can reach the surface water through potential soil erosion of barren land, especially if a major rain storm event occurs soon after bio-liquid/bio-solid application.

Table 6.6 presents the environmental influence of a biogas project village in Fuling district of Chongqing City:

<table>
<thead>
<tr>
<th>Construction items</th>
<th>Investment estimate (Yuan)</th>
<th>Environmental impact</th>
<th>Economic impact</th>
<th>Social impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction of 400 biogas digesters and modification of 400 kitchens, WC's and barns</td>
<td>1268000</td>
<td>Substitute paddy straw, reducing 1.6 t of CH₄, substitution of coal, reducing 514 t of CO₂, 6.76 t of SO₂ and 67.6 t of smoke and dust, protecting equivalent of 8.8 ha of forest.</td>
<td>Reduction in use of pesticide and chemical fertilizers by 44 t per year.</td>
<td>Improve village sanitation level, improve village appearance, improve farmers health status, reduce women's workload and boost their social position.</td>
</tr>
<tr>
<td>Modification of 400 water supply systems.</td>
<td>48000</td>
<td>Improve drinking water quality and preventing ground water pollution.</td>
<td></td>
<td>Improve village water supply quality and ensure their health status.</td>
</tr>
<tr>
<td>One kilometer of village inner road</td>
<td>160000</td>
<td>Impact during construction: Minor dust and noise pollution. Dust and noise pollution will reduce to insignificant levels during operation.</td>
<td>Commodity exchange promotion and economic development.</td>
<td>Facilitate village traffic.</td>
</tr>
<tr>
<td>Vegetable garden: adjust dirt road, water reservoir, drainage, seed and seeding.</td>
<td>140000</td>
<td>Reduction in use of chemical fertilizers and pesticides, improve the soil structure and fertility.</td>
<td>Increase farmers income by 1,200,000 Yuan for the whole village.</td>
<td>Produce green food and organic food, improving social lifestyle and income.</td>
</tr>
<tr>
<td>Technical support and training</td>
<td>20000</td>
<td></td>
<td></td>
<td>Improve technical knowledge level of farmers</td>
</tr>
<tr>
<td>Total</td>
<td>1644000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6.3.1 Biogas leakage risk

Previous experience indicate that in areas where adequate number of technical staff are no present and enough technical training is not provided to the farming communities on use and maintenance of biogas systems, there is a potential risk of unnoticed gas leak that has a potential risk of causing explosions or asphyxiation.

The main causes and form of biogas leakage observed include:

(1) Improper installation of biogas lamp, biogas stove. Too near to flammable materials such as firewood or wooden roof, etc. Improper operation is also a potential cause of fire.

(2) Improper construction of the biogas system. If the pipe connections are not tightly connected and have not been carefully checked by the installers before start of operation, there can potentially be a gas leak from pipe connections that can cause serious accidents such as fire of the local inhabitants. High pressures in the pipes during operation can also cause gas leak. There is also a possibility of accidental leak of the exterior pipes, animals or agricultural machinery that can also cause the pipes to burst.

(3) Upon completion of any biogas digester system and before it is transferred to the farmers, the professional team of experts should fully test the system and ensure that there is no leak or weak points within the system. The experts should also provide a detailed training of the farmers on maintenance of the system and how to check for potential gas leak. If the above process and operation standard is not followed, the possibility of potential risk of gas leak and accidental fire and/or affixiation can be significant.

(4) It appears that there is either not enough training on occupational health and safety for the biogas or the health and safety regulations are not fully followed in some occasions, causing serious accidents and even death. There is a need to train farmers and technical staff on such issues for example, they should be a protocol to prevent staff or farmer to enter the tank for cleaning without the guidance of technical personnel, or prevent use of naked flame (throwing naked flame inside) the tank to check whether there is any residual gas in the tank, a process that has occurred frequently in other areas and have caused severe personal injuries and severe accidents.

The above scenarios are based on real accidents that has previously happened in other similar projects. Therefore, the risk of biogas leakage is something that should be seriously considered by the project proponents and construction/technical crews. Adequate number of engineering and technical personnel should be allocated to the project areas to fully train the farmers on health and safety, and maintenance of the biogas system. Detailed design and operation manual as well as operation standards should be prepared and provided to the farmers and technical staff.

6.3.2 Potential environmental risk of increase in infectious diseases
There are a lot of pathogens in the night soil and livestock manure, mainly Typhoid bacillus, Sub typhoid bacillus, Shigella dysenteriae, poliovirus, Bacillus coli, Schistosome ovum, Hookworm ovum, Roundworm ovum, etc. In order to reduce the number of pathogens to acceptable or non detectable levels, there is a need to allow the anaerobic fermentation process in biogas digester to reduce the number of different pathogens to below allowable detection limit. During the process of anaerobic fermentation, the pathogens cannot be completely killed, but can be reduced to acceptable levels, if adequate retention time is allowed to reduce potential risk to human health.

Table 6-7 The death rate of the pathogens under anaerobic fermentation

<table>
<thead>
<tr>
<th>Pathogenic organisms</th>
<th>High temperature (53 to 55°C)</th>
<th>Medium temperature (35 to 37°C)</th>
<th>Normal temperature (8 to 25°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day</td>
<td>Death rate (%)</td>
<td>Day</td>
</tr>
<tr>
<td>Typhoid bacillus and sub typhoid bacillus</td>
<td>1-2</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>Shigella dysenteriae</td>
<td>1</td>
<td>100</td>
<td>5</td>
</tr>
<tr>
<td>Poliovirus</td>
<td></td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Bacillus coli</td>
<td>2</td>
<td>10$^{-1}$ to 10$^{2}$</td>
<td>21</td>
</tr>
<tr>
<td>Schistosome ovum</td>
<td>Several hours</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td>Hookworm ovum</td>
<td>1</td>
<td>100</td>
<td>10</td>
</tr>
<tr>
<td>Roundworm ovum</td>
<td>2</td>
<td>100</td>
<td>36</td>
</tr>
</tbody>
</table>


The above table indicates that in average, a retention time of 100 days at normal to medium temperatures (the actual temperature range in the anaerobic biogas digester) will reduce most of the major pathogens with the exception of round and hookworm eggs.

6.3.3 Biogas residue fertilizer pollution risk

Table 6.8, representing typical pollutant index of biogas liquid, indicates that even after adequate fermentation of manure in the biogas digester, the levels of COD and NH$_3$-N are still very high. If the bio-liquid or bio-solids are applied in very large quantities to the field as a basal application, there is a risk of potentially polluting water bodies. The application rates for different plants, soil types, and slopes should be provided to the farmers to ensure that such pollution risk is minimized.

Table 6-8 Pollutant index of biogas liquid (mg/L)

<table>
<thead>
<tr>
<th>Item</th>
<th>BOD</th>
<th>COD</th>
<th>NH$_3$-N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value</td>
<td>700-900</td>
<td>800-1000</td>
<td>50-100</td>
</tr>
</tbody>
</table>
7 MITIGATION AND TRAINING PLAN

7.1 Mitigation Plan

To minimize the environment risk associated with the project, a series of corresponding measurements are proposed to prevent or reduce the potential environmental impacts and risks to acceptable levels and to promote the implementation of the project ion an environmentally sound basis. The following section provides a series of procedures that should be included in project design to minimize the environmental impact of the project on the environment.

a) Mitigation Measures During Construction Phase:

- Take preventive measures during construction period to avoid noise levels above the national standards, especially close to sensitive areas such as schools and hospitals;
- Try to re-use solid waste materials that are excavated during excavation of biogas digesters or dispose them at appropriate areas to prevent contamination of natural water bodies. Every effort should be made to prevent the random disposal of excavated material, especially close to water bodies. Waste material should not be piled near river or any other water sources to prevent the possibility of inadvertent water pollution; and
- The biogas digester, biogas pipes and facilities should be installed according to nationally approved specifications to prevent potential leakage/breakdown of the system during operation and to ensure that potential public health and safety risks due to biogas leaks are minimized.

Since the environmental impacts during construction period are minor, short lived, and reversible, no long lasting impact is foreseen. To ensure that the project will not cause any significant negative impact, the above mitigation measures should be exercised so that the project does not cause any significant environmental impact.

b) Mitigation Measures during operation:

- Appropriate retention times must be established for each agro-climatic zone within project area to ensure that pathogenic organisms are killed and their population is reached to below allowed levels before field application to prevent health risk due to pathogens present in untreated night soil and animal manure;
- Volume of biogas bio-solids and bio-liquid fertilizer that is applied to various crops should follow the scientifically acceptable and appropriate rates to prevent potential over application and seepage or runoff of nutrients into surface and ground water bodies. Farmers should be advised on appropriate rates and timing of application to prevent any unforeseen water
contamination and excessive ad untimely vegetative growth that can cause lodging and reduction in crop yield. Methods should be developed and disseminated to the farmers, indicating the appropriate volume of bio-solids and bio-liquids that should be applied to the field based on type of crop and soil to prevent excessive fertilizer pollution of water bodies;

- The newly built sloping farmland for fruit and tea plantations should only be developed on areas with a slope of less than 25° and ground water deeper than 1 meter to prevent water contamination and accelerated soil erosion. In addition, appropriate measures should be taken such as terracing, grass strip, contour planting, etc to reduce/prevent soil and water loss due to improper construction.

7.1.1 Preventive measure to minimize biogas leakage

According to the Civil Biogas Safety Operation Manual, the following procedures should strictly be followed to prevent biogas leakage, potential damages due to biogas leakage, and improper biogas digester and facilities usage:

(1) System installation

Biogas lighting and stove should be properly installed. The biogas stove should be at least 15 cm away from the wall. It is strictly forbidden to pile flammable materials such as firewood or paper near biogas lighting, biogas stove, and biogas piping.

When lighting up the biogas stove with kindling, the kindling should be first lighted. Then slowly turn on the switch. The stove can be fully turned on, only after the stove is lit. If the biogas stove burns abnormally, the air intake control should be adjusted.

The biogas cooker should be installed at least 30 cm above the stove. The biogas cooker must have an independent switch. After turning off the switch of the cooker, the pipe switch must also be turned off.

The biogas heater must be installed outside the bathroom and desulfurizer must be installed. If the heater cannot be lit, the water pressure and voltage should be tested. If not successful, the professional staff should be requested to come for inspection and repair.

(2) Pipes seal

All the joints must be tightened before using the biogas. First connect the gas resource and test all the joints and switches with soapy water. It is strictly forbidden to test leakage with fire.

The manometer must be observed frequently. When the pressure is higher than 8 Kpa, the biogas must be immediately discharged. Discharge gas at the outdoor switch of the biogas digester. It is strictly forbidden to discharge gas indoor or in the sunlight greenhouse to prevent potential explosion and asphyxiation.

If leakage is found (rotten egg smell inside the building), the main gas control should
be turned off immediately and door and windows should be opened for ventilation. Kindling or electricity should not be used at this time to prevent potential fire and explosion.

During the first time to use biogas, it must be tested on the stove. It is strictly forbid to test gas at the pipe end of the biogas digester to avoid potential backfire that can blow up the biogas digester.

Recycled plastic pipes should not be used as biogas pipes. Outdoor pipes must be protected from livestock damage, vehicle damage and freezing and clothes should not be dried on the outdoor pipes.

(3) System operation and maintenance

- Biogas digesters should be tested for water and pressure by technical staff after completion of construction. The system can only be used after the technician is sure that the system does not have any water or gas leak.
- The inlet and outlet of the biogas system must be covered to avoid human or livestock falling into the tank.
- Calcium carbide, all kinds of chemical pesticide, poultry and livestock manure just after disinfection, soapy water, laundry water, etc. should not be allowed to enter the biogas digester to avoid injuring anaerobic organisms in the biogas digester.
- Forbid to fire in the range of 10 m of the biogas digester.
- The activity, such as discharging residue, repairing and maintaining, must be done with the guidance of technicians, who have got the construction license of biogas digester.
- Before entering the biogas digester for repair or cleaning, all solids, slurry, liquid and biogas in the tank must be emptied. Just before entering the tank, a small animal (chicken or duck) should be put inside the tank. If the animal still acts normally after 10 to 15 minutes, it is allowed to enter the tank.
- In no circumstance it is allowed to use open fire in the biogas digester to light the remaining gases since it might cause explosion and serious injuries.
- Before entering the tank, safety belt must be fastened and a second person must be present outside the tank. If person in the biogas digester feels nauseated or dizzy, he must be pulled out immediately and rested on ventilating place. Only non-explosive lamps can be used in the biogas digester and use of open fire or cigarette is strictly forbidden.
- If accident happens and inside the tank, there is a need for immediate rescue of the person trapped in the tank, the rescuing person entering the tank must wear protective clothes and a safety belt. Another rescue person/ambulance man with protection clothes should be available outside the tank for safety reasons.
7.1.2 Mitigation measures to avoid onset of pathogenic diseases

To avoid pathogenic microbes to spread in agricultural fields during application of biogas fertilizer, the following measures should be taken:

- Train farmers in proper application of biogas liquid and solid residues and acceptable application rates. Ensure materials in the biogas digester have been allowed adequate retention time to reduce the pathogens to acceptable levels. The retention time might vary between different agro-climatic zones and different time of the year, but should not be less than 100 days (longer in winter) to avoid inadequate fermentation and to ensure that microbial dead rate has reached below allowable standard levels to prevent the spread of pathogen.

- Prevent farmers to discharge animal manure/night soil directly at the outlet for convenience, which turn the biogas digester to a septic tank.

- Ensure that construction quality of the biogas, toilet and barn follow the project accepted and national standards. Do not allow farmers to build biogas digesters without the guidance of technical staff.

- Provide awareness trainings to the both men and women in farm households in the areas of sanitation, disease prevention, and try to improve farmers self protection habits. Ensure that farmers recognize the potential dangers of using untreated manure or minimally treated bio liquids/bio-solids from the biogas digesters on agricultural field and the potentially harmful health related impacts of such actions.

- Encourage use of advanced technical procedures in operation and maintenance of the biogas systems. Make sure that the joint between the toilet and barn is airproof. Ensure that the animal manure and night soil enter the tank in time to prevent manure to stay in open for a long time to prevent development of a suitable environment for flies and mosquitoes breeding.

7.1.3 Mitigation measures to prevent water pollution

A number of measures are outlined to prevent over use of the biogas fertilizer that can potentially pollute surface and ground-water bodies:

- Provide appropriate methodologies and criteria for liquid and solid biogas digester by-product application as fertilizer on agricultural fields. Strengthen the technical knowledge of local farmers through periodic training on best fertilizer application and management practices to prevent runoff and seepage of macro-nutrient into water resources. Prepare the range of application rate for different soil types, slopes, and agro-climatic zones for application of biogas liquid and residue to prevent/minimize potential over-application and resulting water pollution. The nest application methodology and volume under various conditions should be included in the optimum operation
During fallow time when there is no farming activity, biogas liquid should not be discarded into water bodies. It should be either stored in impervious structures for later use or applied to grasslands/farms at minimal levels to avoid water pollution.

- Use available research data or initiate applied research activities in the area of biogas fertilizer application volume, best application method for different agroclimatic zones, different soil types, various crops, various slope ranges and various period and use the research result to guide the farmers for best fertilizer management practices to reduce potential water pollution and eutrophication.

7.2 Training Requirement

A number of technical and awareness training programs should be conducted at village, township and county level to reduce the potential environmental and health and safety risks of the proposed eco-farming. These training programs should aim at improving the construction standard of biogas systems and to increase level of competence of local farmers in proper operation and management of the biogas digester system as well as correct methods and timing of biogas liquid and residue application in agricultural fields. In addition, the technical services system should be expanded and strengthened to ensure the local farmers receive the required and relevant technical support in a timely manner to avoid potential injuries and accidents. The major training activities that should be carried out include:

- Increasing the number and quality of existing county and township level licensed technical staff and strengthening their technical capabilities to ensure that all project area farming communities receive adequate and timely technical services. Increasing the presence of technical services system within project communities should guarantee that farmers will receive appropriate advice and technical services at the right time to prevent any mishap.

- Strengthen and improve the level of cooperation and communication between agriculture and energy departments.

- Strengthen the current farmer training programs and ensure that all farmers that are involved in the project receive adequate and on-going day-long training on safe operation and management of the biogas digester systems. The scope of current training program should be broaden to incorporate issues that can improve capacity of the local farmers and enable them to better utilize the biogas digester system through continuous training to minimize environment risk.

- Strengthen the awareness program on biogas usage and its safe use through
multi-media and by printing and distributing posters, pamphlets, etc to project farmers.

Table 7.1 present a general outline of proposed courses at the farmer, township and county level.

<table>
<thead>
<tr>
<th>Level</th>
<th>Training content</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer</td>
<td>(1) Training in the use and maintenance of the biogas system.</td>
<td>Improve farmers' understanding of the basic O&amp;M of biogas systems and the appropriate volume and timing of bio-liquid and bio-solids application on agricultural fields and for different crops.</td>
</tr>
<tr>
<td></td>
<td>(2) Training in applied new technologies, optimum usage of biogas liquid and residue in the field, timing and volume of effluent and residue to be applied, and the appropriate retention time before application of bio-slurry to the field.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) Introduce farmers to new crops and breeds</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(4) Provide training on appropriate O&amp;M of the new biogas systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5) Provide training on marketing of the new produce.</td>
<td></td>
</tr>
<tr>
<td>County and township</td>
<td>(1) Train the technical staff in biogas digester construction, design, operation and maintenance.</td>
<td>Enhance technology team's quality and strengthen technologic service.</td>
</tr>
<tr>
<td></td>
<td>(2) Train the county and township technical staff in rural appraisal to allow for a better involvement and participation of farmers and collecting feedback from farmers on performance of the biogas systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(3) Train the county and town technical staff in the supervision and collection of the rural appraisal data.</td>
<td></td>
</tr>
</tbody>
</table>
8 Environmental Supervision Requirements and Indicators Checklist

8.1 Monitoring Plan

The environment supervision is required during two periods; construction period and operation period. The main purposes of supervision are to:

- Timely control, prevention and mitigation of any potential environmental pollution that project activities might cause to reduce potential injury to bio-physical and social environment;
- Timely collection of data and dissemination of feedback to the project management offices on (1) the information related to the degree and range of impacts of project activities on local environmental quality during both construction and operation phases, (2) to provide environmental quality dynamic condition, especially during operation period, and (3) to assist the project team in environmental management of the project.

8.1.1 Construction period

The main potential negative environmental impacts of the project during construction period are minor noise, dust and solid waste during excavation of the biogas digesters. Attention should be made to reduce noise levels, especially when biogas digester excavation site is close to sensitive areas such as schools or hospitals/health clinics or during late night hours to avoid disturbing the local communities.

Project proponents must adhere to the environmental requirements of the project with regard to waste disposal and the waste earth work must not be allowed to reach stream channels during biogas digester excavation. Environmental supervision activities should be implemented through full cooperation between local environmental protection departments and local project offices.

8.1.2 Operation period

- **Waste material resident time supervision:** Studies should be completed to arrive to optimal residents time for effluent in the biogas digester to arrive to pathogen levels that are below approved concentrations standards before application of effluents on agricultural fields as fertilizer. The information should be disseminated to the farmers and the project team should ensure that farmers are aware and should supervise them to ensure that adequate residents time is allowed for complete treatment of animal waste and night soil before their field application as per requirements of project environment risk prevention and project benefit evaluation.
- **Pathogenic field studies:** To prevent the spread of pathogenic diseases and
the reduce the risk that can cause by applying partially treated bio-solids and bio-liquids on agricultural fields, it is proposed to include two visits per year during operation phase to determine the levels of pathogenic microorganism in the effluents that is going to be applied to the field so that correction and can be made to required retention times in actual field condition and in different seasons. It is recommended to use random sampling method, selecting at least two samples in each project county to check for the number of major pathogens such as E.coli, roundworm ovum and hookworm ovum. The data should be compared to the data on Non-hazardous Treatment of Night Soil to check whether the retention times used by the project participant actually meet the national standards and make the appropriate adjustments, accordingly. The supervision data should be submitted to the World Bank and MoA for review during project supervision missions. The detailed supervision items are presented in table 8-1.

8.2 Monitoring Indicators

8.2.1 Monitoring index and scheme

Table 8-1 Environment monitoring plan

<table>
<thead>
<tr>
<th>Project</th>
<th>Time</th>
<th>Frequency</th>
<th>Location</th>
<th>Sample amount</th>
<th>Supervision method</th>
<th>Supervision department</th>
</tr>
</thead>
<tbody>
<tr>
<td>E.coli</td>
<td>Once in summer</td>
<td>Twice a</td>
<td>Feed inlet and outlet of the biogas digester</td>
<td>Random sampling in two counties in each project province</td>
<td>Non-hazardous Treatment of Night Soil</td>
<td>Agriculture environment supervision station or sanitation and health and quarantine station</td>
</tr>
<tr>
<td>Roundworm ovum</td>
<td>and once in winter</td>
<td>a year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hookworm egg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

8.2.2 Reference price

Five provinces are included in the project area and the reference price is provided which can be adjusted according to the actual situations of the project area. The supervision cost should be listed into operation cost to ensure the proper operation of environment supervision.

Table 8-2 Reference price of environment supervision cost

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Unit price (RMB Yuan)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>E.coli</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Roundworm ovum</td>
<td>120</td>
<td>Microbe</td>
</tr>
<tr>
<td>3</td>
<td>Hookworm ovum</td>
<td>120</td>
<td>Microbe</td>
</tr>
</tbody>
</table>
9 Good Management Guideline

Central Project Management Office (CPMO) has published a number of manuscripts entitled “The optimum management guideline” that regulates the construction and maintenance of the biogas digester, usage of biogas and bio-liquid and bio-solid use as fertilizer. The manuscript is prepared to provide project farmers to use biogas and its by-products more efficiently and to avoid any unforeseen accidents and potential negative social and environmental impact. It is a stand-alone document, prepared in both English and Mandarin Chinese to be used as a reference by the farmers and technical personnel. The environmental assessment team is proposing to use this well prepared manuscript as the environmental management guideline for this project. Therefore, the report is not repeated in this report. The report will be available for review upon request.


10 Conclusions and Recommendations

10.1 Conclusion

- The ECO-FARMING Project includes 5 provinces (Autonomous District) of Anhui, Chongqing, Guangxi, Hubei and Hunan with 64 counties (cities or district), all together 538.65 thousand families, which mainly distributes in plains along rivers and gentle slope hilly district. The peasants have the habit of cultivating domestic animals and the waste animal and foliage resource is relatively abundant. The selected project area has good base and conditions to implement the project. The traffic is convenient and the position is reasonable.

- Noise and mill dust are possible to be produced during the project implementation. And in some district, solid waste material will be produced due to road construction. But the influence is short and will stop together with the stop of the construction.

- After the project is completed, it will promote the positive cycle of the ecological conditions. Especially the effective usage of the biogas gas will save energy and effectively reduce the cutting of the forest, which will make the project area keep high percentage of forest covered, reduce water and soil loss, reduce the exhaustion of greenhouse effect gas and polluting gas and do great favor to the improving of local ecological environment. By using biogas digester fertilize, the pollution of agriculture chemical fertilizer and pesticide can be effectively reduced, the soil will be bettered, the soil fertility will be improved and the continuous utilizing of the earth can be promoted. The animal feces will be processed to cut the way of parasite egg and germina’s spread, improve sanitation conditions and benefit the health of the peasants.

- The implementation of the project will improve the production and living conditions, increase employment, enhance peasants’ quality, improve country environmental sanitization and promote social stability of the rural society. Totally 538.65 thousand of agriculture families will directly benefit from the project and their liming and production conditions will be greatly bettered. The implementation of the project will also increase the employment of agriculture surplus labor and attract country women to take part in the construction and increase the women’s social position. To implement the project in minority district will increase the economic income of the minority families, improve their living conditions and increase their civil level.

- In a word, the ECO-FARMING project will mainly positively affect the environment. The complementation of the project will improve the local
environment, promote local economic development and increase living level of local living level, so it is feasible in environment.

10.2 Suggestions

- The provinces, cities and counties in the project area should strengthen the administration of the project. They should improve and expand the technical support system to ensure the success of the project. It is also necessary to pay more attention and increase input in strengthening the available training of technical personnel and farmers to prevent any potential environmental risk and accident to occur.

- The project management offices in all provinces and cities should make the corresponding environmental management and supervision plans based on these reports findings, strength environmental supervision management capability of the personnel during the construction to prevent discharge of solid waste material into adjacent rivers and water bodies. They should be aware of potential risk of soil erosion, water and soil loss and potential increase in sediment load if adequate attention is not given to appropriate soil protection in the hilly areas. They will be responsible for implementing and making sure that the environmental supervision is implemented during construction and operation.

- Project should attempt to provide adequate funds and manpower to strengthen proposed relevant research activities as are outlined in Chapter 8 of this report applied to agricultural fields, optimum retention times are established to prevent introduction of pathogenic microbes to the environment, and reduce potential risk of explosion and asphyxiation by gas leak due to either poor construction, or poor maintenance.