BIOGAS PRODUCTION

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ACRONYMS

BCR	Benefit-cost ratio
CBO	Community-Based Organisation
DFES	Debt-for-Environment Swap
EBRD	European Bank of Reconstruction and Development
E&M	Electrical and mechanical
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GEL	Georgian Currency Lari
GESI	Georgian Energy Security Initiative
GHG	Greenhouse gases
GNERC	Georgian National Energy Regulatory Commission
GTZ	Deutsche Gesellschaft für Technische Zussamenarbeit (Technical Cooperation Agency of Germany)
GWEM	Georgian Wholesale Electricity Market
HPP	Hydropower Plant
IHA	International Hydropower Association

IRR	Internal Rate of Return
JSC	Joint-Stock Company
KfW	Bank Kreditanstalt für Wiederaufbau (German Bank for Reconstruction)
NPV	Net Present Value
O&M	Operation and Maintenance (costs)
PDF	Project Development Facility
PPA	Power Purchase Agreement
RNPV	Rate of NPV
SDS	State Department for Statistics of Georgia
SME	Small and Medium Enterprises
Tetri	0.01 GEL
TA	Technical Assistance
TPP	Thermal Power Plant
UMCOR	United Methodist Committee on Relief
USAID	US Agency for International Development
USC	US cent
USD	US Dollar
VAT	Value Added Tax
WB	World Bank

PHYSICAL UNITS

g	Gramme
GWh	Gigawatt-hours
kg	Kilogramme
kt	Kilotonne
kW	Kilowatt
kWh	Kilowatt-hours
Mm^3	Million cubic metres
MW	Megawatt
PJ	Petajoule
tC	Tonnes of carbon
tCO_2	Tonnes of carbon dioxide
TJ	Terajoule

SYNTHESIS

Current experience in Georgia clearly indicates that there are no technical barriers to the successful operation of biogas reactors. Different types of equipment have been tested with good results. Some are easier to operate, but less effective in producing biogas. Others require more attention to operate, but produce significantly more biogas. These different types of biogas reactors respond to different needs.

In addition, current experience indicates that the production of biogas reactors has not taken off in Georgia. Most efforts in this area are financed by international organisations, suggesting a problem in scaling up. This is because many farmers are still not aware of this technology and, most importantly, would have serious difficulty finding the USD 500 that the cheapest biogas reactor would cost. Resources made available through a debt-for-environment swap (DFES) could act as a financial facility to promote the expansion of the biogas sector.

The report includes a brief description of donor activities and lessons learned in the field of biogas production and possible links with DFES.

A stakeholder analysis has been carried out. Households, local businesses, engineering and consulting companies in the field of biogas have been identified as main stakeholders and their incentives and capacities assessed.

This report identifies two types of model projects for DFES support. The first is **Mesophilic Model Projects** while the second is **Thermophilic Model Projects**. Their main characteristics are the following:

- The small-scale mesophilic bioreactor has a $6m^3$ volume and requires the equivalent of waste material generated from 4 cows. The temperature of the reactor is $25\text{-}40^0$C. Modern mesophilic bioreactors can produce 0.2-0.4 m^3 per m^3 of installation.
- A small-scale thermophilic bioreactor has a $6m^3$ volume and requires the equivalent of waste material generated from 5 cows or more. The temperature of the reactor is $50\text{-}55^0$C. Modern thermophilic bioreactors can produce 2-6 m^3 per m^3 of installation.

For each case, the report presents economic calculations for three scenarios. The first scenario uses current costs and current efficiency rates in biogas production. The other 2 scenarios assume that investment costs decrease and that the efficiency of biogas reactors increases over time. The costs of biogas reactors are estimated on the basis of implemented projects and future development forecasts, and include capital costs and operation and maintenance (O&M) costs.

The benefits generated by the model projects have been estimated for two cases. The first case assumes that biogas will be used in gas stoves with maximum efficiency of 60%, replacing energy from burning wood. Economic benefits generated by these projects include:

- Reduction of uncontrolled forest cutting, and thereby mitigation of risks such as avalanches, landslides, etc. (Over the last decade, especially in rural areas of Georgia, people have been using mainly firewood for cooking, heating and hot water.)

- Contribution to the value of the standing forest saved. This "shadow price" of afforestation/reforestation is estimated on the basis of analysis of different projects developed in Georgia.
- Improved living conditions for the population (e.g. people will spend less, or no, time, energy and finance on wood collection).
- Indoor pollution will be reduced.
- Electricity generation (especially in the case of thermophilic bioreactors, which produce more biogas than necessary for generating heat).
- Higher education levels (e.g. during short winter days, schoolchildren will be able to study by electric light powered by biogas).
- Better access to information: with electricity from biogas, the rural population can watch TV, which is a vital source of information, especially in wintertime, when access roads to mountainous regions are closed.
- Reduced greenhouse gas (GHG) emissions by avoiding methane emissions and using wood in heat production and electricity.

Projects were assumed to be economically feasible if the Net Present Value (NPV) is positive, the Internal Rate of Return (IRR) is ≥ 20% and show a payback period of ≤ 7 years. Under these conditions, **thermophilic projects with improved efficiency and decreased costs are economically feasible**. However, it should be noted that a number of social benefits difficult to monetise have not been included in this analysis which does not allow to present the full picture of all benefits that could be obtained through such projects.

The financial calculations used the same three scenarios described above and assumed that 20% of investments would be the responsibility of farmers (co-financing)[41]. The remaining 80% would be covered by a combination of grants and loans. The financial calculations were carried out for scenarios in which the share of the grant increases from 0 to 10%, 20%, 30%, 40% and 50% of the total DFES contribution.

The results of the financial calculations show that under current costs and efficiency rates of biogas production, at least 50% of capital costs might need to be covered by a grant component. Later, if technology improvements result in increased biogas productivity and a reduction of capital costs, then the grant component may be reduced and even excluded by 2010-2012.

The sensitivity analysis shows that IRR sharply responds to changes in capital costs and the share of the grant component in total investment. As for other parameters, their impact is relatively minor. This indicates that in evaluating project proposals, attention should be given to ensure that the estimation of capital costs has been properly done.

The capital costs of the project pipeline have been estimated for mesophilic and thermophilic bioreactors. The cost of mesophilic reactors is in the range of USD 720 - 900. It is assumed that DFES would support the installation of 50-100 mesophilic units in 3 regions of Georgia per year (western, eastern and southern Georgia). Under this assumption, the annual capital costs would amount to USD 108 000-216 000. The cost of thermophilic reactors is in the range of USD 3 340-4 100, and it is assumed that DFES would support the installation 15-20 of these bioreactors per year. Under this assumption, annual capital costs would amount to USD 50 000-82 000. **Taking into account both types of reactors, it is calculated that the annual project pipeline disbursement would amount to approximately USD 160 000 - 300 000**.

[41] For the purposes of comparison, the World Bank project "Reduction of Pollution from the Agricultural Sector" had 80% of biogas reactor costs covered by a GEF grant and 20% financed by farmers (cash, building materials, manpower).

1. TECHNICAL EXPLOITABLE POTENTIAL OF THE BIOGAS SECTOR

As a definition, the technical potential is the estimation of the total national capacity technically feasible. The economic potential is based on the technical potential constrained by the results obtained through a cost/benefit analysis (profitability requirement). Several authors have explored the issue and this report presents a summary of the results. Table 1 shows the estimated potential for biogas production from animal waste in Georgia (TACIS, 1997).

Table 1. Potential for Biogas Production from Animal Waste

No	Biomass Source	Total Amount, Thousand Heads	Biomass, kg/Day per Unit	Total Biomass, Tonnes/Day	Biogas Amount Obtained from 1 kg of Biomass, m^3	Total Biogas Production, Thousand m^3 / Day
1	Livestock	916	45	41 260	0.04	1 650
2	Pigs	328	9	2 955	0.06	177.3
3	Sheep, Goats	580	4	2 321	0.06	139.2
4	Poultry	7 580	0.17	1 288	0.07	90.1
5	Horses	22	35	786	0.04	314

Source: TACIS, 1997.

The TACIS study focused on the technical and economic potential of biogas production in the country (including municipal solid waste). The analysis shows that the technical potential stands at 200 GWh while the economic potential is at 50 MGh, still a sizeable figure.

Livestock data serve as a main source for the estimation of biogas potential. The official statistics on livestock numbers are presented in Tables 2 and 3.

Table 2. Number of Livestock (Thousand Heads)

Year	Cattle	Pigs	Sheep and Goats
1985	1 652.6	1 133.4	1 955.7
1986	1 645.5	1 173.4	1 979.6
1987	1 634.7	1 150.4	1 938.5
1988	1 584.8	1 117.8	1 920.5
1989	1 547.8	1 099.2	1 894.0
1990	1 426.6	1 027.8	1 833.5
1991	1 298.3	880.2	1 618.1
1992	1 207.9	732.5	1 469.6
1993	1 002.6	476.2	1 191.6
1994	928.6	365.1	958.1
1995	944.1	366.9	793.3
1996	973.6	352.6	724.8
1997	1 008.0	332.5	652.0
1998	1 027.2	330.3	583.5
1999	1 050.9	365.9	586.7
2000	1 122.1	411.1	633.4
2001	1 177.4	443.4	627.6
2002	1 180.2	445.4	659.2

Source: State Department for Statistics (SDS).

Table 2 shows that the number of livestock has increased over the last years and has reached about 1.2 million. The number of large agriculture farms (with 20-50 or more livestock) is also increasing.

Table 3. Number of Livestock in Agriculture Enterprises and Households, (Thousand Heads)

	2001			2002		
	Agriculture Enterprises	Households	Total	Agriculture Enterprises	Households	Total
Cattle	6.8	1 170.6	1 177.4	5.2	1 175.0	1 180.2
of which: Milk-cows	2.8	643.5	646.3	2.2	676.1	678.3
Pigs	0.8	442.6	443.4	0.2	445.2	445.4
Sheep and goats	27.8	599.8	627.6	25.7	633.5	659.2
Sheep	27.4	519.5	546.9	25.3	542.2	567.5
Goats	0.4	80.3	80.7	0.4	91.3	91.7
Horses	0.4	34.5	34.9	0.4	38.2	38.6

Source: State Department for Statistics.

Table 4 shows livestock numbers per capita by regions.

Table 4. Population (Thousands) and Number of Livestock by Regions

Region	Population			Livestock							
				Total				Per Capita			
	Total	Urban	Rural	Cattle	Of which: Milk-Cows	Pigs	Sheep and Goats	Cattle	Of which: Milk-Cows	Pigs	Sheep and Goats
Georgia	**4 371.5**	**2 284.8**	**2 086.7**	1 180,221	678 270	445 364	659 156				
Tbilisi	**1 081.7**	**1 081.6**	**0.1**	2 378	2 204	1 549	613				
Tbilisi	1 073.3	1 073.3									
Tskhneti	8.3	8.2	0.1								
Adjara	**376.0**	**166.4**	**209.6**	**122 717**	**66 311**	**741**	**17 020**	**0.203**	**0.111**	**0.000**	**0.031**
Batumi		121.8									
Keda	20.0	1.2	18.8	12 124	5 704	12	1 222	0.489	0.230	0.000	0.049
Kobuleti	88.1	31.7	56.4	17 991	11 778	656	892	0.026	0.017	0.001	0.001
Shuakhevi	21.9	1.0	20.9	28 581	14 011		4 147	1.104	0.541	0.000	0.160
Khelvachauri	90.8	9.5	81.3	15 781	11 721	73	3 738	0.109	0.081	0.001	0.026
Khulo	33.4	1.1	32.3	48 240	23 097		7 021	1.276	0.611	0.000	0.186
Guria	**143.4**	**37.5**	**105.8**	**51 302**	**30 654**	**36 476**	**11 439**	**0.153**	**0.089**	**0.139**	**0.041**
Ozurgeti	78.8	27.5	51.2	23 447	13 971	10 627	4 770	0.039	0.023	0.018	0.008
Lanchkhuti	40.5	7.9	32.6	15 919	10 311	12 527	2 063	0.187	0.121	0.147	0.024
Chokhatauri	24.1	2.1	22.0	11 936	6 372	13 322	4 606	0.367	0.196	0.410	0.142
Racha - Lechkhumi and Kvemo Svaneti	**51.0**	**9.6**	**41.4**	**40 693**	**22 007**	**20 912**	**5 382**	**0.479**	**0.257**	**0.247**	**0.071**
Oni	9.3	3.3	5.9	6 918	3 966	3 292	249	0.309	0.177	0.147	0.011
Ambrolauri	16.1	2.5	13.5	12 486	7 091	4 254	1 484	0.480	0.273	0.164	0.057
Lentekhi	9.0	1.7	7.3	8 538	4 413	5 914	587	0.540	0.279	0.374	0.037
Tsageri	16.6	2.0	14.7	12 751	6 537	7 452	3 062	0.516	0.265	0.302	0.124
Samegrelo and Zvemo Svaneti	**466.1**	**183.1**	**283.0**	**202 180**	**112 092**	**134 307**	**19 604**	**0.204**	**0.110**	**0.130**	**0.022**
Poti		47.1		2 091	1 399	1 420	30	0.002	0.001	0.002	0.000
Zugdidi	167.8	68.9	98.9	52 012	29 799	38 829	2 895	0.035	0.020	0.026	0.002
Abasha	28.7	6.4	22.3	23 445	12 758	10 257	268	0.361	0.196	0.158	0.004
Martvili	44.6	5.6	39.0	31 078	15 459	21 266	4 330	0.407	0.203	0.279	0.057
Mestia	14.3	2.6	11.7	13 730	6 270	4 900	3 100	0.556	0.254	0.198	0.126
Senaki	52.1	28.1	24.0	24 454	13 472	16 042	2 268	0.042	0.023	0.027	0.004
Chkhorotsku	30.1	5.0	25.1	19 765	10 215	16 049	2 558	0.395	0.204	0.320	0.051

Tsalenjikha	40.1	13.8	26.4	13 542	8 508	11 558	3 283	0.082	0.052	0.070	0.020
Khobi	41.2	5.6	35.6	22 063	14 212	13 986	872	0.303	0.195	0.192	0.012
Imereti	**699.7**	**323.8**	**375.9**	**266 615**	**134 456**	**95 623**	**35 868**	**0.234**	**0.113**	**0.088**	**0.034**
Kutaisi		186.0		1 820	1 378	309	200	0.000	0.000	0.000	0.000
Tkibuli	31.1	14.5	16.7	12 644	5 232	4 826	1 372	0.078	0.032	0.030	0.008
Tskhaltubo	73.9	16.8	57.0	41 114	19 268	9 584	2 486	0.183	0.086	0.043	0.011
Chiatura	56.3	13.8	42.5	22 852	10 015	6 938	4 967	0.127	0.055	0.038	0.028
Baghdati	29.2	4.7	24.5	15 147	6 732	7 752	2 907	0.316	0.140	0.162	0.061
Vani	34.5	4.6	29.8	24 077	9 583	10 706	5 138	0.456	0.181	0.203	0.097
Zestaponi	76.2	25.8	50.5	26 102	14 200	13 111	2 830	0.046	0.025	0.023	0.005
Terjola	45.5	5.5	40.0	35 338	20 172	13 960	4 578	0.461	0.263	0.182	0.060
Samtredia	60.5	31.7	28.7	25 967	15 925	6 464	3 402	0.039	0.024	0.010	0.005
Sachkhere	46.8	6.7	40.2	22 587	11 756	8 402	5 588	0.266	0.139	0.099	0.066
Kharagauli	27.9	2.4	25.5	21 074	8 812	7 200	1 304	0.562	0.235	0.192	0.035
Khoni	31.7	11.3	20.4	17 893	11 383	6 371	1 096	0.134	0.085	0.048	0.008
Kakheti	**407.2**	**84.8**	**322.4**	**116 002**	**68 761**	**73 938**	**243 306**	**0.123**	**0.075**	**0.073**	**0.245**
Telavi	70.6	21.8	48.8	12 104	7 250	14 301	31 394	0.025	0.015	0.029	0.065
Akhmeta	41.6	8.6	33.1	20 250	11 968	13 156	62 580	0.224	0.132	0.145	0.692
Gurjaani	72.6	10.0	62.6	7 421	5 665	3 173	13 300	0.057	0.044	0.025	0.103
Dedoplistkaro	30.8	7.7	23.1	18 477	6 455	12 052	35 066	0.248	0.087	0.162	0.471
Lagodekhi	51.1	6.9	44.2	21 991	13 599	10 236	25 410	0.244	0.151	0.113	0.282
Sagarejo	59.2	12.6	46.6	19 007	10 745	5 814	43 350	0.110	0.062	0.034	0.251
Sighnagi	43.6	8.2	35.4	7 111	5 568	5 000	15 880	0.079	0.062	0.056	0.176
Kvareli	37.7	9.0	28.6	9 641	7 511	10 206	16 326	0.109	0.085	0.115	0.184
Mtskheta - Mtianeti	**125.4**	**32.1**	**93.3**	**54 652**	**41 244**	**24 365**	**60 336**	**0.145**	**0.109**	**0.066**	**0.167**
Mtskheta	64.8	13.0	51.8	14 499	10 324	2 358	5 912	0.080	0.057	0.013	0.033
Kazbegi	5.3	1.8	3.5	3 086	2 623	992	23 828	0.247	0.210	0.079	1.906
Akhalgori	7.7	2.4	5.3	4 596	3 261	3 347	9 537	0.266	0.188	0.193	0.551
Dusheti	33.6	10.8	22.8	23 149	17 911	10 716	17 247	0.177	0.137	0.082	0.132
Tianeti	14.0	4.0	10.0	9 322	7 125	6 952	3 812	0.311	0.238	0.232	0.127
Samtskhe - Javakheti	**207.6**	**65.5**	**142.1**	**99 447**	**63 673**	**8 228**	**90 082**	**0.250**	**0.158**	**0.022**	**0.241**
Adigeni	20.8	2.3	18.4	18 535	8 989	1 505	2 255	0.620	0.301	0.050	0.075
Aspindza	13.0	3.2	9.8	10 180	5 345	404	10 678	0.395	0.207	0.016	0.414
Akhalkalaki	61.0	9.8	51.2	25 939	19 122	3 527	33 835	0.223	0.164	0.030	0.290
Akhaltsikhe	46.1	23.5	22.7	15 773	9 935	727	3 722	0.032	0.020	0.001	0.008
Borjomi	32.4	20.4	12.1	9 199	5 516	1 048	5 604	0.022	0.013	0.002	0.013
Ninotsminda	34.3	6.3	28.0	19 821	14 766	1 017	33 988	0.283	0.211	0.015	0.486
Kvemo Kartli	**497.5**	**186.5**	**311.0**	**142 553**	**84 405**	**22 892**	**154 891**	**0.167**	**0.102**	**0.024**	**0.185**
Rustavi		116.4		553	403	524	438	0.000	0.000	0.000	0.000
Bolnisi	74.3	17.7	56.7	14 886	10 698	2 526	7 818	0.064	0.046	0.011	0.033
Gardabani	114.3	16.1	98.2	49 464	25 638	6 184	58 229	0.191	0.099	0.024	0.225
Dmanisi	28.0	3.4	24.6	20 314	13 111	1 957	19 421	0.488	0.315	0.047	0.467
Tetritskaro	25.4	6.8	18.6	15 825	10 629	6 553	16 597	0.248	0.166	0.102	0.260
Marneuli	118.2	23.7	94.5	27 382	13 180	3 530	32 615	0.048	0.023	0.006	0.057
Tsalka	20.9	2.4	18.5	14 129	10 746	1 618	19 773	0.463	0.352	0.053	0.648
Shida Kartli	**314.0**	**113.8**	**200.2**	**81 682**	**52 463**	**26 333**	**20 615**	**0.059**	**0.038**	**0.018**	**0.017**
Gori	148.7	49.5	99.2	29 037	19 230	10 639	5 741	0.027	0.018	0.010	0.005
Kaspi	52.2	15.2	37.0	19 087	13 629	4 312	8 804	0.101	0.072	0.023	0.047
Kareli	50.4	10.7	39.7	18 671	10 498	5 686	4 259	0.127	0.072	0.039	0.029
Khashuri	62.7	38.3	24.4	14 887	9 106	5 696	1 811	0.019	0.012	0.007	0.002

Source: State Department for Statistics.

Table 4 shows that there is high potential for biogas production in several areas of Georgia. These are districts where the number of livestock per capita is 0.4 or more. In this category, we have the following areas:

- Khulo 1.276
- Shuakhevi 1.104
- Adigeni 0.620
- Kharagauli 0.562

- Mestia 0.556
- Lentekhi 0.540
- Tsageri 0.516
- Keda 0.489
- Dmanisi 0.488
- Tsalka 0.483
- Ambrolauri 0.480
- Vani 0.456
- Martvili 0.407

According to expert estimations, the total annual amount of manure produced is about 15-20 million tonnes, of which 3-5 million tonnes can be processed for biogas (120-200 million m^3 annually) and for fertiliser (1-3 million tonnes annually). This could replace 70-120 million m^3 of natural gas equivalent.

The potential for biogas is even more relevant when considering that wood is the main energy source in rural areas. According to the energy balance produced by the State Department for Statistics of Georgia (SDS), total energy consumption in 2001 was 125.6 PJ, of which 64.5 PJ (51%) originated from wood consumption. Wood is essentially burnt in low efficiency stoves. Switching from wood consumption to biogas use would have a positive effect on forest conservation.

2. BIOGAS TECHNOLOGIES

The development of biogas technologies in Georgia started in 1993-1994 with the assistance of GTZ (Technical Cooperation Agency of Germany). Technical support provided by GTZ allowed Georgian experts and engineers to study advanced designs and adapt technologies to Georgian climatic and economic conditions.

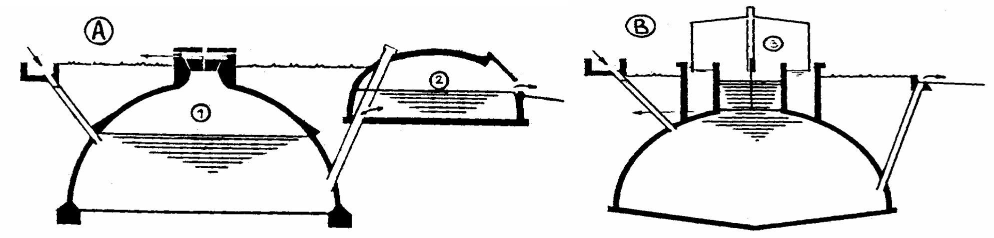
The process of biogas production takes place in anaerobic conditions and in different temperature diapasons. There are psychrophilic (temperature diapason 10-25^{0}C), mesophilic (25-40^{0}C) and thermophilic (50-55^{0}C) regimes of bioconversion. Biogas production in a thermophilic regime is much higher than for the mesophilic and psychrophilic regimes. Modern thermophilic bioreactors can produce 2-6 m^3 per m^3 of installation, which amounts to 5-15 kg of waste on a dry mass base (or 50-150 kg of wet mass). For mesophilic biogas installations, these values are 0.2-0.4 m^3 per m^3 of installation and 0.5-1 kg on a dry mass base (or 5-10 kg of wet mass). Biogas reactors, working in a thermophilic regime, can be introduced in agricultural farms where the number of livestock exceeds 5. Biogas produced on such farms can be used not only for cooking and heating water, but for dairy production as well.

2.1. Local Experience in the Development and Construction of Biogas Reactors

In Georgia, there are a number of engineering companies, research/engineering institutes and individuals with experience in the field of biogas production. Among them, the best known are Bioenergia Ltd., Konstruktori Ltd. and the Georgian National Centre of High Technology.

In the 1990s, Bioenergia Ltd. developed small-scale mesophilic biogas reactors of the fixed-dome and floating-dome types (Figure 1). These systems are easy to operate but less effective in terms of biogas production. Taking into account the local conditions, these reactors represent the most attractive technologies for the majority of households with 1-2 livestock. Later on, Bioenergia also developed more effective mesophilic biogas reactors with a 6 m^3 volume, but these require the waste material of at least four livestock.

Figure 1. Small-Scale Biogas Reactors of Fixed-Dome (A) and Floating-Dome (B) Types



Source: TACIS, 1997.

The first bioreactor was constructed in Sasireti, Kaspi in 1994. In that same year, Bioenergia Ltd. was awarded a patent, and in 1996 its brochure “Construction and Maintenance of Biogas Installations” was published and distributed with support from “World Vision”. In 1994-1996, bioreactors were installed in Gurjaani, Dedoplistskaro, Gardabani, Tsalka and Chakvi, some of them with the assistance of the US Agency for International Development (USAID).

The publication of this brochure had a noticeable impact. As a result, about 60 bioreactors were installed by interested farmers, using mainly their own resources. Table 5 presents some information on these individual biogas installations.

Table 5. Bioreactors Constructed by Individual Farmers

N	Location	Farmer	Year of Construction	Volume of Bioreactor, m^3
1	Kaspi, Sasireti	Onezashvili	1994	3
2	Gurjaani, Velistsikhe	Mgebrishvili	1995	7
3	Dedoplistskaro, Kvemo Kedi	Tsiklauri	1996	7
4	Dedoplistskaro, Gamarjveba	Gogochuri	1996	9
5	Dedoplistskaro, Kasris Tskali	Gonashvili	1996	3
6	Chakvi	Kintsurashvili	1996	7
7	Zestaponi, Argveta	Meladze	1995	1
8	Zestaponi, Sakara	Shvelidze	1996	3
9	Zestaponi, Tvrini	Chankvetadze	1996	6
10	Zestaponi, Tvrini	Kveladze	1996	6
11	Zestaponi, Puti	Katamadze	1995	4
12	Zestaponi, Kvaliti	Guniava	1996	20
13	Zestaponi, Sazano	Kobakhidze	1996	9
14	Gardabani	Khardziani	1996	4
15	Gardabani	Talakhadze	1996	4
16	Marneuli, Tsereteli	Mumladze	1996	6
17	Chiatura, Mgvimevi	Memarnishvili	1996	6
18	Tbilisi, Agaraki	Gagnidze	1996	10
19	Tbilisi, Navtlugi	Antidze	1996	9
20	Marneuli, Teleti	N/A	1995	5
21	Lagodekh, Ninigori	N/A	1995	6
22	Telavi, Kurdgelauri	N/A		
23	Gori, Khidistavi	Talashaze	1996	
24	Gori, Dzevera	N/A	1996	7
25	Zugdidi, Akhalkakhati	Tuzbaia		
26	Zugdidi, Narazevi	N/A	1996	4
27	Vani, Dikhashkho	Maglakelidze	1996	6
28	Kareli, Ruisi	Kutkhashvili	1996	
29	Akhmeta, Shenako	N/A	1996	4
30	Borjomi, Kvabiskhevi	Maisuradze	1996	4
31	Kareli, Tamarisi	N/A	1996	7
32	Kharagauli, Tamarisi	Grigalashvili	1995	6
33	Khobi, Akhalnigula	Janjgava	1997	7
34	Tskaltubo, Gvishtibi	Ioseliani	1995	1
35	Martvili, Abedati	Zarkua	1996	4
36	Khoni	Lezhava	1997	14
37	Mtskheta, Ksani	Mchedlidze	1996	4
38	Mtskheta, Gorovani	Magaldadze	1996	6
39	Gurjaani	Avakashvili	1996	
40	Zestaponi, Didi Gantiadi	Samkharadze	1996	2

Source: UNDP.

During the preparation phase of this report, a team of local and international consultants visited the bioreactor in Didi Gantiadi. This bioreactor, constructed in 1996, is still in good operating condition. In spite of the limited manure input (the family had one cow only), the produced biogas is sufficient for cooking purposes throughout the whole year.

Figure 2. Bioreactor in Didi Gantiadi

Other promising experiences followed those of 1994-1996. In 1999, with financial support from the Coordinating Centre for the Development of Agriculture Projects, Bioenergia Ltd. constructed four small-scale bioreactors in the Terjola region. Two of them were of the heat-insulated floating-dome type equipped with a solar collector, and the two others were of the horizontal fixed-dome type.

Three different types of biogas installations have been tested in Georgia with support from the World Bank project "Reduction of Pollution from the Agricultural Sector". In 2002, the project installed 12 bioreactors in the Khobi, Chkhorotsku and Tsalenjikha regions. Eight bioreactors were of the floating-dome type, two of the fixed-dome Chinese type, and the other two – were locally improved versions of the fixed-dome type. In 2003, the Coordinating Centre announced a tender for the construction of another 45 units. The winners were Bioenergia Ltd. and Gamon Joint-Stock Company (JSC). The Coordinating Centre constructed more than 100 installantions in 2005.

In parallel to the work of the Coordinating Centre, Bioenergia constructed a 30-m^3 volume bioreactor in Sachkhere with financial support from the United Methodist Committee on Relief (UMCOR), and 9 bioreactors in Akhaldaba under the MERCY Corps community mobilisation programme. The construction of bioreactors is also planned along the Baku-Tbilisi-Ceihan (BTC) oil pipeline under the BTC Social Investment Programme.

After 10 years of work, bioreactor designs are getting better. In 2003, and with support from the European Bank for Reconstruction and Development (EBRD), Bioenergia manufactured 6 construction sets in order to reduce the cost and construction time of biogas installations. As a result, construction time was reduced from 1.5 months to 10 days. Different types were tested and are being used by Bioenergia and Gamon JSC.

In August 2004, the aid organisation CARE[42] announced a tender for the construction of 5 bioreactors for 5-15 livestock in the Tsalka region, characterised by cold winter conditions (up to -25^0C).

[42] Humanitarian organisation fighting global poverty.

Barriers to scaling up

The total number of bioreactors installed in Georgia equals several hundred, i.e. only 0.1-0.2% of households use biogas. Most of the bioreactors are of the mesophilic type and only few are of the thermophilic type, mostly because the latter is more costly and requires more biomass resources.

These experiences suggest two conclusions. The first is that there are practically no technical barriers to the successful operation of biogas reactors in Georgia. Different types have been tested, showing good results. Some are easier to operate but less effective in producing biogas. Others require more attention to operate, but produce significantly more biogas. These different types respond to different needs.

The second conclusion is that the production of biogas reactors has not taken off. Most efforts are financed by international organisations, suggesting a problem in scaling up. This is because many farmers are still not aware of this technology and, most importantly, would have serious difficulty finding the USD 500 that the cheapest bioreactor would cost. During the preparation of this report, the DFES team of local and international experts confirmed that in the absence of a financial facility (e.g. soft loan), the use of biogas reactors in Georgia would remain very limited for the foreseeable future. DFES could be the needed financial facility.

2.2. Lessons Learned

Technologies

- The use of biogas reactors improves living conditions of households. People in rural Georgia, particularly women, spend a significant amount of their time on wood gathering and stockpiling. The use of biogas frees a lot of time while reducing the need for hard physical work (wood felling and stockpiling).
- Bioreactors provide the expected output (biogas production) in real conditions.
- The costs of bioreactors of all types, especially of thermophilic ones, remain high.
- The amount of biogas spent to keep substrate temperature within the limits of 50-55^{0}C (thermophilic bioreactors) did not exceed 25% of produced biogas, even under the worst climatic conditions (average temperature -8^{0}C).
- Visual aids (brochures, booklets, TV broadcasts) play a significant role in promoting biogas technologies.
- The interest in biogas technologies developed/adapted for Georgia is spreading to neighbouring countries. Armenia has expressed interest in thermophilic bioreactors, and a one-week training course has already been conducted. Similar training is also planned for Azeri and Serbian experts.

Operators and consumers

- Knowledge about biogas and access to this information by farmers is very limited. They usually show low interest at the initial stages of biogas development.
- The more farmers put into the project themselves, the longer they maintain bioreactors in working condition.
- The interest of farmers in biogas is growing, as a result of pilot implementation and information campaigns.
- In spite of an increased interest, most farmers do not have the financial capacity to install bioreactors.

- The lack of a strategy to finance biogas projects and the absence of credit lines for farmers impede the take-off of biogas production in Georgia.

Critical factors for biogas development

The following factors impede or delay the establishment of biogas reactors in Georgia:

- Cold and dry climate. The mountainous regions of Georgia, where livestock breeding represents the main type of business, are characterised by cold winter conditions, while the lowlands have hot and dry summers. Bioreactor technologies must therefore be adjusted to local climatic conditions.
- Low and irregular biogas demand.
- Daily amount of manure less than 20 kg.
- Difficulties in manure collection.
- Absence of local building materials.
- Lack of fresh water (which is used in bioreactors).
- Low income of farmers.
- High construction costs.
- Low qualification of constructors.

Many of the above-mentioned critical factors are determined not so much by the region, but rather by the number of cows and pasture location, the grazing regime, etc.

Some of the main factors that promote or facilitate the establishment of biogas reactors are listed below:

- Average annual temperature above 20^0C.
- Daily amount of manure in excess of 30 kg.
- Need for fertilisers (the by-product of biogas generation is manure without methane, which is a good fertiliser).
- Possibility to construct a bioreactor in the proximity of a cowshed and kitchen.
- Affordable local construction costs.
- Interest of farmers in energy efficiency and environmental protection.
- Existence of local building materials and gas stoves.
- Existence of qualified constructors in the village or town.

3. CAPITAL AND OPERATION AND MAINTENANCE COSTS OF MODEL PROJECTS

3.1. Mesophilic Model Projects

The small-scale mesophilic bioreactor has a 6-m^3 volume and requires the equivalent of waste material from 4 cows.

Capital and operation and maintenance (O&M) costs have been estimated based on the experience of pilot projects implemented in Georgia over the last few years. The capital costs of bioreactors constructed by Bioenergia Ltd. in 2002-2003 are about USD 200 per cubic metre of bioreactor. This amount includes administrative and transport costs and consultancy fees. The capital costs of bioreactors constructed by farmers themselves without donor support are lower, but usually these gains are at the expense of quality. According to expert estimations, the capital costs of small-scale (up to 6-8 m^3) bioreactors can be reduced to USD 120 per cubic m^3 in case of mass production (above 100 units per year).

Bioreactors require very small operational and maintenance costs. Annual O&M costs can be estimated at 1% of capital costs. Table 6 shows capital and annual O&M costs for a mesophilic model reactor. The costs for 2005 represent current costs, while those for future years are estimations based on expected increases in efficiency.

Table 6. Capital and Operational & Maintenance Costs of a Mesophilic Model Bioreactor

Category	Date of Construction		
	2005 (Model 1)	2006-2010 (Model 2)	2011-2015 (Model 3)
Volume, m^3	6	6	6
Capital cost of 1 m^3, USD	150	120	120
Total capital cost, USD	900	720	720
Annual O&M costs, USD	9.00	7.20	7.20
Specific daily biogas production, m^3/m^3	0.30	0.45	0.55
Daily biogas production, m^3	1.8	2.7	3.3
Heat content of biogas, MJ/m^3	22.5	22.5	22.5
Capacity of bioreactor, kW	0.469	0.703	0.859
Daily heat production, kWh	11.3	16.9	20.6
Annual biogas production, m^3	657	986	1205
Annual heat production, MWh	4.106	6.159	7.528

Source: Own estimates.

3.2. Thermophilic Model Projects

A small-scale thermophilic bioreactor has a 6-m^3 volume and requires the equivalent of waste material from 5 cows or more.

Capital and O&M costs have been estimated based on the experience of pilot projects implemented in Georgia over the last few years. The capital costs of thermophilic bioreactors constructed by the Georgian National Centre of High Technologies vary between USD 600 - 750 per cubic metre of bioreactor. This includes administrative and transport costs and consultancy fees. According to the estimations of local experts, the capital costs of small-scale (up to 6-8 m^3) thermophilic bioreactors can be reduced by 25 - 35%

in case of mass production (about 50 units per year). The annual O&M cost of thermophilic bioreactors is about 2% of capital costs.

Table 7 shows capital and annual O&M costs for a thermophilic model reactor. The costs for 2005 represent current costs, while those for future years are estimations based on expected increases in efficiency.

Table 7. Capital and Operation and Maintenance Costs of a Thermophilic Model Bioreactor

Category	Date of Construction		
	2005 (Model 4)	2005-2010 (Model 5)	2010-2015 (Model 6)
Volume, m^3	6	6	6
Capital cost of 1 m^3, USD	600	450	390
Total capital cost, USD	3 600	2 700	2 340
Annual O&M costs, USD	72.00	54.00	46.80
Specific daily biogas production, m^3/m^3	2.00	4.00	6.00
Daily biogas production, m^3	12	24	36
Heat content of biogas, MJ/m^3	22.5	22.5	22.5
Capacity of bioreactor, kW	3.125	6.250	9.375
Daily heat production, kWh	75.0	150.0	225.0
Annual biogas production, m^3	4 380	8 760	13140
Annual heat production, MWh	27.375	54.750	82.125

Source: Own estimates.

4. ECONOMIC ANALYSIS OF BIOGAS PRODUCTION

The development of biogas production from animal manure can generate benefits both at a national and household level.

In rural areas of Georgia, people use mostly firewood for cooking and heating purposes and for obtaining hot water. The uncontrolled forest cutting that took place in the country over the last decade greatly increases the risk of dangerous phenomena, such as avalanches, landslides, etc.. Besides, the woodstoves that people use are of very low efficiency.

The benefits generated by the model projects have been estimated for two cases. The first case assumes that biogas will be used in gas stoves having a maximum efficiency of 60% and it will replace energy from burning wood. Specifically, biogas obtained from such projects will be characterised by:

- Heat content: 7.5 GJ/m^3 or 13.2 GJ/t;
- Efficiency of wood stoves: 60%; and
- All produced biogas will be consumed.

When considering the benefits of replacing wood as an energy source with biogas, one should take into account the contribution this will make to the value of the standing forest that is saved. This "shadow price" of afforestation/reforestation has been estimated for different projects developed (but not yet implemented) in Georgia. The cost of 1 m^3 wood varies in the range of USD 4 - 9 (see Table 8) by regions and it is expected to increase in areas where forest is very scarce.

The conservation of forests plays an important role for local communities with regard to flood control and water source protection. Uncontrolled cutting and logging, which took place during the last decade, has led to a decrease of underground water resources and initiated soil erosive processes in many regions of Georgia which have resulted in serious damage.

Table 8. Some Indicators of Afforestation Projects

Project Type	Carbon Content, tC/Tonne Biomass	Investment, USD	Change in Carbon Stock, tCO_2	Change in Carbon Stock, tC	Volume of Wood, m^3	Specific Cost, USD/m^3
Afforestation[43]	0.50	153 462	13 906	3 793	7 585	20.23
Energy plantations[2]	0.45	5 058 000	640 000	174 545	387 879	13.04
Nabadkhevi[44]	0.57	0.50	351 000	18 564	65 251	5.38
Ksani[3]	0.57	0.50	455 000	21 296	74 854	6.08
Red Bridge[3]	0.57	0.50	325 000	15 280	53 708	6.05
Dendrology Park[3]	0.57	0.50	299 000	19 651	69 073	4.33
Total			**6 641 462**	**253 129**	**1 249 439**	**5.32**

Source: Own estimates.

In addition, biogas utilisation will also generate social benefits. People will spend less or no time, energy and finances on wood collection; indoor pollution will be reduced; when biogas is used for electricity production, it will contribute to the improvement of education levels (in short winter days, school children will no longer have to do their lessons by candlelight), and better access to information. Due to a very limited electricity supply, the rural population cannot watch TV, which in wintertime, when access roads to mountainous regions are closed, is a vital source of information). Monetisation of these benefits is difficult and has not been included in the economic calculations.

Moreover, the development of biogas production under DFES will generate GHG reductions by decreasing methane emissions and replacing wood as an energy source (for more details, see Section 10) at the price of 5 USD/tCO_2 (or USD 18/tC).

The second case assumes that biogas will be used for electricity generation in gas generators (having efficiency of 35%) and will replace electricity purchased at the usual price of 8.6 Tetri/kWh = 44.8 USD/MWh. If biogas is used for electricity generation and replaces energy otherwise produced by existing facilities, benefits generated by DFES will equal the cost of electricity produced otherwise. Since biogas reactors used for electricity generation would most probably operate within an isolated network / direct customers, the cost of replaced energy will include generation, transmission and dispatch costs. According to Resolution 14 of the Georgian National Energy Regulatory Commission (GNERC) of 15 August 2003, the weight-average electricity generation tariff is set at 2.667 Tetri/kWh (1.40 USC/kWh), and the weight-average electricity transmission and dispatch tariff is set at 1.61 Tetri/kWh (0.84 USC/kWh). Consequently, benefits generated by the DFES will equal 2.24 USC/kWh.

Other benefits derived from biogas are reduced GHG emissions. Based on the energy balance data for 2001 (amount of electricity generated by hydro power plants (HPPs), by thermal power plants (TPPs), amount of fuel combusted in TPPs) and the future share of HPPs in total energy generation, the carbon emission factor was calculated for Georgia's electricity system. On average, the generation of 1 kWh of electricity is

[43] Source: ICF Consulting. *Carbon Sequestration through Afforestation and Reforestation in Georgia*. 2001.

[44] Project developed by the National Agency on Climate Change.

related to 198 g of CO_2 emissions or to 198 tCO2/GWh (for more information, see Section 14 of this report). The world price for a tonne of CO2 reduced at present equals USD 5 (or USD 18/t C), which means that 1 kWh of electricity produced by the projects implemented under DFES would generate an additional 5 * 198 / 1 000 000 = 0.1 USC. Taking into account the above calculations, the electricity produced by projects implemented under DFES would generate 2.24 + 0.1 = 2.34 USC/kWh.

For the sake of simplicity, it was assumed that O&M costs remain constant during the lifetime of the mesophilic and thermophilic biogas reactor projects. Tables 9-10 present the input data and the results of the economic calculations.

Table 9. Input Data

Case 1 - Biogas Replaces Wood						
Client: OECD/DFES	**Model Project**					
Country: Georgia	**Mesophilic**			**Thermophilic**		
Currency: USD (2004)	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Annual biogas production, m^3	657	986	1 205	4 380	8 760	13 140
Annual heat production, MWh	4.1	6.2	7.5	27.4	54.8	82.1
Annual heat production, GJ	15	22	27	99	197	296
Efficiency of gas stoves	80%	80%	80%	80%	80%	80%
Efficiency of wood stoves	60%	60%	60%	60%	60%	60%
Annual amount of wood replaced by biogas (w/o different efficiencies), m^3	1.97	2.95	3.61	13.12	26.25	39.37
Annual amount of wood replaced by biogas, m^3	2.62	3.94	4.81	17.50	34.99	52.49
Price of wood due to afforestation/reforestation, USD/m^3	5.32	5.32	5.32	5.32	5.32	5.32
Annual benefit (price of afforestation/reforestation), USD	14	21	26	93	186	279
Annual GHG reduction, tCO_2	5	8	10	36	72	108
Income due to GHG reduction, USD/tCO_2	5	5	5	5	5	5
Annual income due to GHG reduction, USD	27	41	50	180	360	540
Total annual benefit, USD	**41**	**61**	**75**	**273**	**546**	**819**
Increase of income, %	2%	2%	2%	2%	2%	2%
Capital (investment) costs, USD	900	720	720	3 600	2 700	2 340
Operation and maintenance costs, USD	9	7	7	72	54	47
Case 2 - Biogas Replaces Electricity						
Client: OECD/DFES	**Model Project**					
Country: Georgia	**Mesophilic**			**Thermophilic**		
Currency: USD (2004)	**Model 1**	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Annual biogas production, m^3	657	986	1 205	4 380	8 760	13 140
Annual heat production, MWh	4.1	6.2	7.5	27.4	54.8	82.1
Efficiency of gas generators	35%	35%	35%	35%	35%	35%
Annual amount of electricity replaced by biogas, MWh	1.4	2.2	2.6	9.6	19.2	28.7
Electricity generation, transmission and dispatch tariff USD/kWh	0.0224	0.0224	0.0224	0.0224	0.0224	0.0224
Electricity generation emission factor, tCO_2/GWh	198	198	198	198	198	198
Income due to GHG reduction, USD/tCO_2	5	5	5	5	5	5
Income generated by 1 kWh of electricity produced by DFES project, which replaces otherwise produced energy, USD/kWh	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Total income generated by 1 kWh of electricity produced by DFES project, USD/kWh	0.0234	0.0234	0.0234	0.0234	0.0234	0.0234
Total annual benefit, USD	**96**	**144**	**176**	**640**	**1,281**	**1,921**
Increase of income, %	0%	0%	0%	0%	0%	0%
Capital cost of bioreactor	900	720	720	3 600	2 700	2 340
Cost of gas generator	200	250	300	500	700	1 000
Total capital costs, USD	1 100	970	1 020	4 100	3 400	3 340
Operation and maintenance costs, USD	11	10	10	82	68	67

Source: Own estimates.

Table 10. Results of Economic Calculations

	Model Project 1	Model Project 2	Model Project 3	Model Project 4	Model Project 5	Model Project 6
Case 1 - Biogas Replaces Wood						
NPV, USD	-603	-360	-301	-2 085	-100	1 396
ERR	1%	8%	10%	5%	20%	35%
BCR	0.20	0.37	0.45	0.33	0.87	1.50
RNPV	0.33	0.50	0.58	0.42	0.96	1.60
Payback, years	22	12	10	15	6	3
Case 2 - Biogas Replaces Electricity						
NPV, USD	-577	-279	-195	-1 210	1 922	4 473
ERR	6%	13%	16%	13%	36%	56%
BCR	0.34	0.58	0.67	0.61	1.47	2.24
RNPV	0.48	0.71	0.81	0.70	1.57	2.34
Payback, years	13	8	7	8	3	2

Note: *NPV – Net present value;*
ERR – Economic rate of return;
BCR – Benefit-cost ratio;
RNPV – Ratio of NPV (= NPV/(NPV + Investment).

Projects were assumed to be economically feasible if the NPV is positive, the IRR ≥ 20% and show a payback period of ≤ 7 years. Under these conditions, thermophilic projects of improved efficiency and decreased costs are economically feasible. However, it should be noted that a number of social benefits difficult to monetise have not been included in this analysis which actually does not allow to present the full picture of all benefits that could be obtained through such projects.

5. FINANCIAL VIABILITY OF BIOGAS PRODUCTION

The evaluation of the financial viability of biogas reactors uses a discount rate of 21% and a lifetime of 25 years. The analysis includes capital and O&M costs and revenues, but not taxes and loan service. The discount rate for people investing in biogas is based on the longest Treasury bill on the market (16%), which also matches the rate at which banks lend for a period of 5 years to buy property and other capital assets. The additional 5% captures the risk premium set by users of biogas reactors.

The annual income generated from biogas projects is the amount of money people save by no longer having to buy wood or electricity to meet their energy needs. The price of wood is estimated at USD 15/m^3, and the current electricity tariff for customers in rural areas is 8.6 Tetri/kWh or 4.5 USC/kWh.

The financial calculations assume that 20% of investments would be the responsibility of farmers (co-financing).[45] The remaining 80% would be covered by a combination of grants and loans. Tables 11a and 11b below present calculations for grants, with their shares of the total DFES contribution increasing from 0 to 10%, 20%, 30%, 40% and 50%.

Table 11-a. Financial Calculations – Case 1

Share of Farmers = 20%; Interest on Loan = 6%; Payback Period = 7 years

Case 1. Biogas Replaces Wood						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
No Grant; Loan 80%						
NPV, USD	-515	-280	-219	-1 731	253	1 786
IRR		4%	8%	1%	26%	80%
BCR	0.26	0.50	0.61	0.42	1.11	1.93
RNPV	0.28	0.51	0.62	0.40	1.12	1.95
Grant 10%; Loan 70%						
NPV, USD	-456	-232	-171	-1 492	432	1 941
IRR		6%	10%	2%	31%	89%
BCR	0.29	0.55	0.67	0.45	1.21	2.09
RNPV	0.28	0.54	0.66	0.41	1.23	2.18
Grant 20%; Loan 60%						
NPV, USD	-396	-185	-123	-1 254	611	2 096
IRR		8%	12%	3%	36%	99%
BCR	0.32	0.60	0.73	0.50	1.33	2.29
RNPV	0.27	0.57	0.71	0.42	1.38	2.49

[45] For comparison purposes, the World Bank project "Reduction of Pollution from the Agricultural Sector" had 80% of biogas reactor costs covered by a GEF grant and 20% financed by farmers (cash, building materials, manpower).

Grant 30%; Loan 50%						
NPV, USD	-336	-137	-76	-1 015	790	2 251
IRR	-0.3%	10%	15%	5%	43%	108%
BCR	0.35	0.67	0.82	0.55	1.47	2.54
RNPV	0.25	0.62	0.79	0.44	1.58	2.92
Grant 40%; Loan 40%						
NPV, USD	-277	-89	-28	-777	968	2 406
IRR	1.4%	13%	18%	7%	51%	118%
BCR	0.40	0.76	0.92	0.61	1.64	2.84
RNPV	0.23	0.69	0.90	0.46	1.90	3.57
Grant 50%; Loan 30%						
NPV, USD	-217	-42	20	-538	1 147	2 561
IRR	3.6%	17%	23%	10%	59%	128%
BCR	0.46	0.87	1.06	0.70	1.86	3.22
RNPV	0.20	0.81	1.09	0.50	2.42	4.65
Grant 60%; Loan 20%						
NPV, USD	-158	6	68	-300	1 326	2 716
IRR	6.5%	22%	29%	14%	68%	138%
BCR	0.54	1.02	1.25	0.80	2.15	3.72
RNPV	0.12	1.04	1.47	0.58	3.46	6.80
Grant 70%; Loan 10%						
NPV, USD	-98	54	115	-61	1 505	2 871
IRR	10.6%	28%	37%	19%	78%	148%
BCR	0.65	1.24	1.51	0.95	2.55	4.40
RNPV	-0.09	1.75	2.60	0.83	6.57	13.27
Grant 80%; Loan 00%						
NPV, USD	-38	102	163	177	1 684	3 026
IRR	16.3%	36%	45%	26%	87%	158%
BCR	0.83	1.57	1.92	1.17	3.12	5.39
RNPV						

Note: *NPV – Net present value;*
IRR – Internal rate of return;
BCR – Benefit-cost ratio;
RNPV – Rate of NPV.

Table 11-b. Financial Calculations – Case 2

Share of Farmers = 20%; Interest on Loan = 6%; Payback Period = 7 years

Case 1. Biogas Replaces Wood						
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
No grant; Loan 80%						
NPV, USD	-551	-299	-234	-1 353	1 250	3 324
IRR		8%	11%	7%	45%	103%
BCR	0.36	0.60	0.70	0.60	1.45	2.21
RNPV	0.37	0.61	0.71	0.59	1.46	2.24
Grant 10%; Loan 70%						
NPV, USD	-478	-235	-167	-1 082	1 475	3 546
IRR	0.8%	9%	13%	8%	52%	113%
BCR	0.39	0.66	0.77	0.65	1.57	2.40
RNPV	0.38	0.65	0.77	0.62	1.62	2.52
Grant 20%; Loan 60%						
NPV, USD	-405	-171	-99	-810	1 700	3 767
IRR	2.2%	12%	16%	11%	60%	123%
BCR	0.43	0.73	0.85	0.71	1.72	2.63
RNPV	0.39	0.71	0.84	0.67	1.83	2.88
Grant 30%; Loan 50%						
NPV, USD	-332	-107	-32	-539	1 925	3 988
IRR	3.9%	14%	19%	13%	68%	132%
BCR	0.48	0.81	0.95	0.79	1.91	2.91
RNPV	0.40	0.78	0.94	0.74	2.13	3.39
Grant 40%; Loan 40%						
NPV, USD	-259	-42	36	-267	2 151	4 209
IRR	6.1%	18%	23%	17%	77%	142%
BCR	0.54	0.92	1.07	0.88	2.13	3.25
RNPV	0.41	0.89	1.09	0.84	2.58	4.15
Grant 50%; Loan 30%						
NPV, USD	-187	22	103	4	2 376	4 431
IRR	8.8%	23%	29%	21%	87%	152%
BCR	0.62	1.05	1.23	1.00	2.42	3.69
RNPV	0.43	1.08	1.34	1.00	3.33	5.42
Grant 60%; Loan 20%						
NPV, USD	-114	86	171	276	2 601	4 652
IRR	12.5%	29%	36%	27%	96%	162%
BCR	0.73	1.23	1.44	1.16	2.79	4.26
RNPV	0.48	1.44	1.84	1.34	4.82	7.96

Grant 70%; Loan 10%						
NPV, USD	-41	150	238	547	2 826	4 873
IRR	17.5%	36%	44%	34%	106%	173%
BCR	0.88	1.49	1.75	1.37	3.30	5.04
RNPV	0.63	2.55	3.34	2.34	9.31	15.59
Grant 80%; Loan 00%						
NPV, USD	32	215	306	819	3 051	5 094
IRR	24.2%	45%	53%	42%	116%	183%
BCR	1.12	1.89	2.22	1.68	4.05	6.18
RNPV						

Note: *NPV – Net present value;*
IRR – Internal rate of return;
BCR – Benefit-cost ratio;
RNPV – Rate of NPV.

Table 12 shows biogas projects that have a positive NPV and an IRR of at least 21%.

Table 12. Summary Results – Projects with Positive NPV and IRR of at Least 21%

Share in Financing	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Case 1. Biogas Replaces Wood						
Owners	20%	20%	20%	20%	20%	20%
Grant	80%	68%	60%	73%	No grant	No grant
Loan	0%	12%	20%	7%	80%	80%
Case 2. Biogas Replaces Electricity						
Owners	20%	20%	20%	20%	20%	20%
Grant	55%	13%	No grant	13%	No grant	No grant
Loan	25%	67%	80%	67%	80%	80%

The marginal (minimum) values of the grant share that ensures an IRR of 21% for model projects 1 and 4 equal 80% and 73% respectively if biogas is used for heat production, and 55% and 13% if biogas is used for electricity production.

6. SENSITIVITY ANALYSIS

This section provides a sensitivity analysis for model projects 1 and 4, which show an IRR of at least 15%. The sensitivity analysis evaluates the impact on IRR of changes in capital costs, annual O&M costs, the grant share, the loan interest and payback period. The simulations capture deviations from plus-minus 40% in an incremental step of 10%.

The sensitivity analysis shows that IRR sharply responds to changes in capital costs. Therefore, further development of technologies and a subsequent decrease of costs have a crucial importance. For mesophilic bioreactors, the share of the grant component in total investment is also important. As for the other parameters, their impact is relatively minor. This indicates that in evaluating project proposals, attention should be focused on ensuring that the estimation of capital costs are properly done.

Figures 3 and 4 show the results of Tables 13 and 14.

Table 13. Sensitivity Analysis – Changes in Absolute Values of IRR

Model Project	Changes of Parameters	IRR after Changes in Variable				
		Capital Costs	Annual O&M Costs	Share of Grant	Loan Interest	Payback Period
1	-40%	42%	23%	12%	22%	20%
	-30%	34%	22%	14%	22%	21%
	-20%	29%	22%	16%	22%	20%
	-10%	24%	21%	18%	21%	21%
	0%	21%	21%	21%	21%	21%
	10%	18%	21%	24%	21%	22%
	20%	16%	20%	28%	21%	22%
	30%	14%	20%	32%	20%	22%
	40%	13%	20%	36%	20%	23%
4	-40%	52%	23%	19%	23%	19%
	-30%	39%	23%	20%	23%	21%
	-20%	31%	22%	20%	22%	20%
	-10%	25%	22%	21%	21%	21%
	0%	21%	21%	21%	21%	21%
	10%	18%	20%	21%	21%	22%
	20%	15%	20%	22%	20%	23%
	30%	13%	19%	23%	20%	23%
	40%	12%	19%	23%	19%	24%

Table 14. Sensitivity Analysis – Deviations from a Base IRR of 15%

Model Project	Changes of Parameters	Relative Changes of IRR after Changes in Variable				
		Capital Costs	Annual O&M Costs	Share of Grant	Loan Interest	Payback Period
1	-40%	102%	7%	-42%	5%	-6%
	-30%	63%	5%	-34%	3%	-1%
	-20%	36%	3%	-24%	2%	-3%
	-10%	16%	1%	-13%	1%	-1%
	0%	0%	0%	0%	0%	0%
	10%	-13%	-2%	15%	-1%	3%
	20%	-23%	-4%	32%	-2%	4%
	30%	-31%	-6%	51%	-4%	5%
	40%	-39%	-7%	72%	-5%	7%
4	-40%	147%	10%	-9%	10%	-10%
	-30%	87%	8%	-7%	7%	-2%
	-20%	47%	5%	-5%	4%	-5%
	-10%	20%	2%	-2%	2%	-2%
	0%	0%	0%	0%	0%	0%
	10%	-15%	-3%	2%	-2%	6%
	20%	-27%	-5%	4%	-5%	8%
	30%	-36%	-8%	7%	-7%	10%
	40%	-44%	-10%	10%	-9%	15%

Figure 3. Changes of IRR due to Changes of Base Parameters for Model Project 1

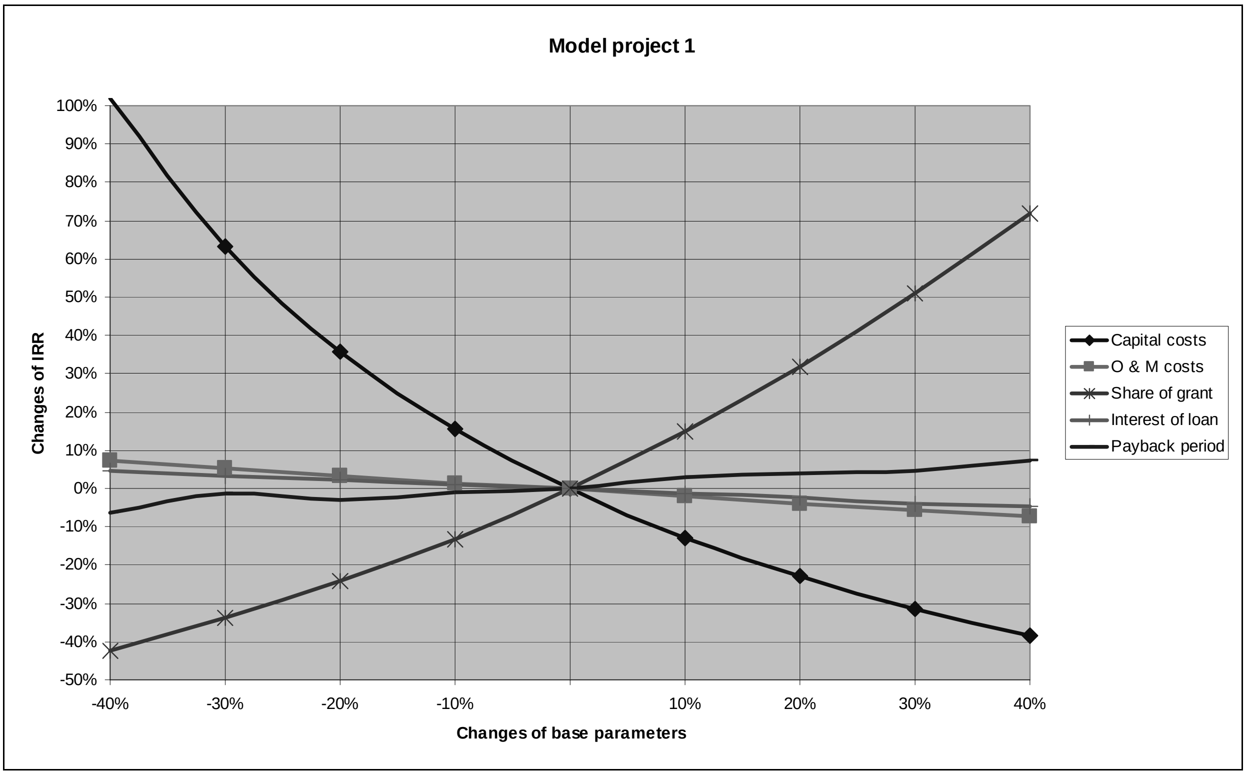
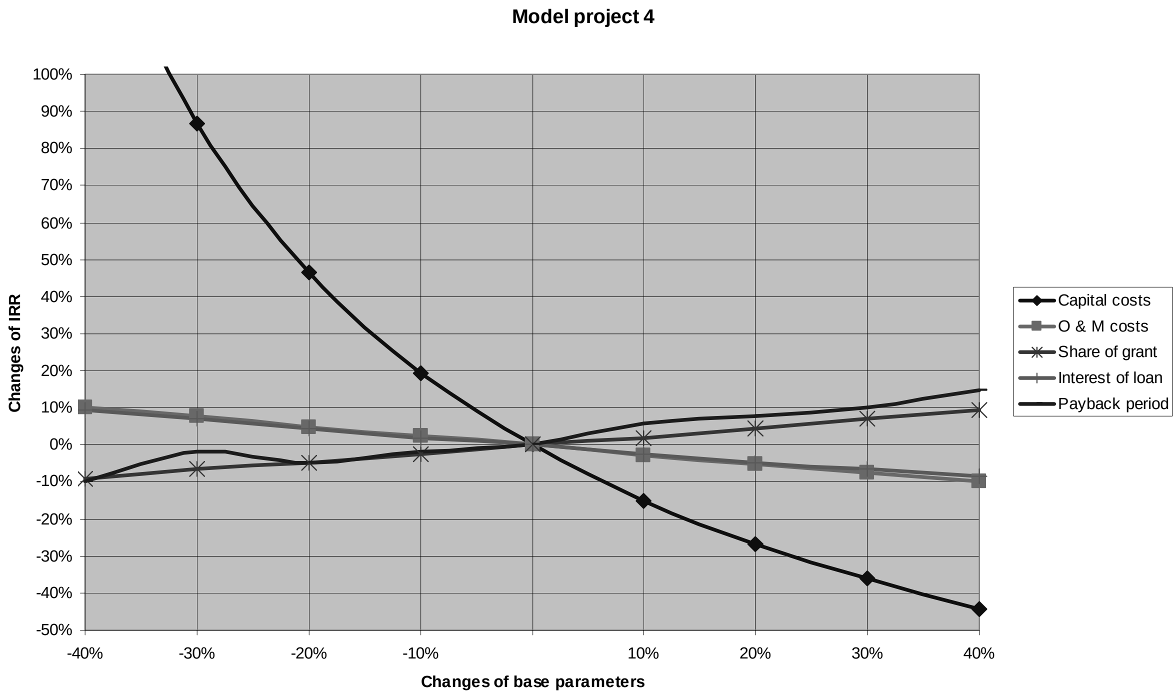


Figure 4. Changes of IRR due to Changes of Base Parameters for Model Project 4



7. MARKET POTENTIAL OF BIOGAS REACTORS

The results of the financial calculations show that at present at least 50% of capital costs should be covered by a grant component. Later on, if technology improvements result in increased biogas productivity and a reduction of capital costs, then the grant component could be reduced and even excluded by 2010-2012.

In spite of the great willingness of farmers to use biogas reactors, their low capacity to afford them will significantly decrease the scale of biogas development in Georgia. All interviewed farmers expressed their readiness to allocate required resources as an equity share. However, it is difficult to estimate how many farmers will be able to cover their part of costs, even with a grant component.

Unfortunately, there are no exact statistical data on population income by regions. Available data are presented in Table 15.

Table 15. Average Monthly Income and Expenditures per Household by Urban and Rural Areas, GEL

	Urban Areas	Rural Areas	Urban Areas	Rural Areas
	2001		2002	
Income total	**170.3**	**177.1**	**200.5**	**252.7**
Of which:				
Contractual employment	79.6	23.9	90.2	27.7
Self-employment	33.1	14.9	42.1	18.3
Sales of agricultural products	2.8	41.3	3.6	56.2
Income from asset holdings (lease of property and interest income)	2.5	0.5	1.4	0.6
Pension, stipends, family allowances, benefits	12.6	12.0	10.4	5.5
Remittances from abroad	10.8	6.0	14.1	7.1
Remittances from relatives	12.9	6.1	16.0	7.8
Non-cash income	16.0	72.4	22.7	129.5
Total consumption expenditure	**275.0**	**277.1**	**289.0**	**292.3**
Of which:				
Food alcohol, tobacco	131.6	79.9	136.9	87.1
Clothing and footwear	13.8	10.4	14.0	10.7
Household items	29.9	21.0	8.0	7.1
Health care	14.0	8.8	18.5	12.6
Fuel and electricity	19.8	14.1	24.8	14.9
Transportation	17.4	7.0	32.5	18.3
Education and recreation	10.7	3.7	18.8	7.3
Other cash expenditure on consumption	12.1	6.0	13.0	4.8
Other expenditure - total	25.7	28.8	50.0	50.2
Consumption in kind	25.7	126.3	22.6	129.5
Total cash expenditure	**274.9**	**179.7**	**316.4**	**213.0**
Total expenditure	**300.6**	**305.9**	**339.0**	**342.4**

Source: State Department of Statistics.

Table 15 shows that expenditures of rural households exceeded their incomes in 2002. The 2004 level of income is expected to be higher due to the higher prices of agricultural products, but this level will still not allow the majority of households to invest in biogas reactors. However, the environmental policy of the new government will lead to a decrease in cutting wood and a subsequent increase in wood prices. This fact, along with biogas awareness campaigns and other programmes (including DFES), is likely to increase interest in biogas development.

Another option, which can promote loan repayment, is the establishment of community-based organisations (CBOs). CBOs have already been established in communities covered by the Community Development Component of the Georgian Energy Security Initiative (GESI) in order to implement mini hydropower projects, including payment collection. Moreover, Bioenergia has developed a programme that includes the establishment of CBOs, which will not only construct bioreactors, but also collect agriculture products from farmers (loan recipients), sell these products, and re-pay loans.

8. CAPITAL NEEDS FOR THE ENTIRE PROJECT PIPELINE

8.1. Capital Cost for Mesophilic Bioreactors

The cost of mesophilic reactors is in the range of USD 720 - 900. DFES could support the installation of 50-100 biogas units in 3 regions of Georgia per year (western, eastern and southern Georgia). Under this assumption, the annual capital costs would amount to USD 108 000 - 216 000.

8.2. Capital Cost for Thermophilic Bioreactors

The cost of thermophilic reactors is in the range of USD 3 340 - 4 100. Annually, 15 - 20 bioreactors could be constructed with DFES support. Under this assumption, the annual capital costs would amount to USD 50 000 - 82 000.

9. RISKS AND RISK MITIGATION MEASURES

The major risks identified are of technical, infrastructure and financial nature. These include:

Technical Risks

- Low efficiency (lower than expected) of bioreactors, even if technical requirements are met; and
- Low quality of construction, especially when farmers construct bioreactors themselves.

These risks can be mitigated by ensuring that appropriate technologies are supported in different regions of Georgia and by providing training and technical assistance to farmers.

Infrastructure Risks

- Lack of appliances for biogas (gas stoves, gas generators) would limit potential benefits; and
- Thermophilic bioreactors may produce more biogas than needed by the owner and, if infrastructure is weak and biogas demand is low, then this would not allow biogas use on a full scale.

Financial Risks

Due to their poor financial situation, farmers in some regions may not be able to provide even the required 20% of the total cost. For the same reason, it might be difficult for farmers to repay loans obtained through the DFES facility. In this case, either the co-financing conditions should be relaxed or the application for DFES resources rejected.

10. ESTIMATION OF GREENHOUSE GASES (GHG) ABATEMENT POTENTIAL

In order to calculate the net GHG reductions associated with DFES, this section presents a scenario without the DFES programme (the "baseline") and one with it (the "alternative"). The baseline scenario includes emissions from manure as well as emissions from existing fuel (e.g. wood). The alternative case includes the emission from biogas.

Table 16. Parameters of Biogas, Methane and Wood

Methane Content in Biogas	Methane Density kg/m^3	Methane Global Warming Potential in CO_2 Equivalent	Heat Content of Biogas MJ/m^3	Biogas Emission Factor t C/TJ	Heat Content of Wood GJ/t	Wood Density, t/m^3	Wood Emission Factor t C/TJ
50%	0.710	21	22.500	30.6	13.198	0.569	29.9

Source: UNDP.

Our estimates of GHG reductions are based on Table 16 and on the data presented in Table 8. It has been assumed that DFES would support 700 mesophilic (model 2) and 200 thermophilic (model 5) reactors. The calculations of the GHG emission reductions are presented in Table 17.

Table 17. GHG Emission Reductions Potential

Model Project	Annual Emissions in Baseline Case		Annual Emissions in Alternative Case (t CO_2)	Annual GHG Reduction (t CO_2)	GHG Reductions in 25 Years (t CO_2)
	Methane Emissions due to Anaerobic Digesting (t CO_2 Equivalent)	Emissions due to Wood Combustion (t CO_2)			
2	7.347	2.488	3.241	8.1	203
4	65.306	22.115	28.812	72.0	1 800
Total					**501 769**

Source: UNDP.

As Table 17 shows, the total GHG reduction for a period of 25 years would be 501 769 tonnes.

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MUNICIPAL WASTE MANAGEMENT

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ACRONYMS

DFES	Debt-for-Environment Swap
EC	European Community
EIA	Environmental Impact Assessment
EU	European Union
GDP	Gross Domestic Product
GEL	Georgian Currency Lari
MENRP	Ministry of Environment and Natural Resources Protection
MSW	Municipal Solid Waste
MSWMS	Municipal Solid Waste Management Systems
NACE	Statistical Classification of Economic Activities in the European Community (from French - Nomenclature générale des activités économiques des Communautés européennes)
O&M	Operation and Maintenance (costs)
SCGD	Sanitary Cleansing and Greenery Department (of Poti)
SCS	Sanitary Cleansing Service (of Rustavi)
SDS	State Department for Statistics of Georgia
SEE	State Environmental Examination
USAID	US Agency for International Development
USD	US Dollar
VAT	Value Added Tax
WB	World Bank

PHYSICAL UNITS

ha^2	Square hectare
km	Kilometre
m^3	Cubic metre

SYNTHESIS

Per capita waste generation in Georgia is far below that in developed countries, where income and consumption levels are higher. Georgia also produces less municipal solid waste (MSW) per USD 1 000 GDP than other countries because of its undeveloped economy. The largest components of MSW are food waste and mixed paper (paper/cardboard), followed by textiles, metals, wood and glass. Together, these items represent 89% of all waste.

The most significant point sources of groundwater contaminants are municipal landfills and industrial waste disposal sites. The primary method of waste disposal in Georgia is landfilling. The soil type and water tables have not always been taken into account when determining the location of landfills. Many landfills lack liners and leachate collection control systems. Groundwater contamination from landfill leachate is of concern at a number of sites. Some legal waste sites have been identified as a serious threat to the environment, for example the one at Poti, which is located right on the bank of the river Rioni without even the most basic precautions to avoid contamination of international water bodies. The most serious problem though remains the illegal disposal of waste. Traditional places are isolated locations along the coast and river margins. The final destination of the substantive amount of waste generated in Georgia is the Black Sea and the Kura River basin.

Settlements along the Black Sea coastal area and in the Kura River basin are affected by one or more of the following problems:

- No new waste disposal sites are under consideration, in spite of the fact that in many locations current landfills are either hardly accessible, close to saturation or pose a serious health and environmental risk.
- Landfills are located along rivers or coastal areas. These sites are often flooded as a result of which waste is transported to international water bodies.
- The current status of legal and illegal dumping poses a major health hazard to the population. Pigs and cows often search for food in unfenced landfill sites.
- Solid waste is often dumped illegally. Traditional spots are isolated sites along river courses and the Black Sea coast.
- Little knowledge of, and skills in, modern methods of integrated water management and solid waste disposal techniques are available in the country.

This report explores the feasibility of several **model projects** for financing from debt-for-environment swaps (DFES). These model projects constitute good examples of affordable remedial actions aimed at decreasing pollution of international water bodies and risks to public health. These model projects include:

1. Fencing of landfills. This type of project aims at ending trespassing and the transportation of garbage into residential areas and/or international water bodies.
2. Separation of landfills from river courses and coastal waters. The location of a landfill right on the edge of a water body is not unusual in Georgia. This type of project aims at avoiding regular flooding of landfills and the subsequent pollution of international water bodies.

3. Expansion of existing waste collection systems. Many of the waste collection systems only partially cover urban settlements. It is common to see towns or cities with waste collection systems that leave large sections with no or limited service. This type of project explores the feasibility of partial expansion of existing waste collection systems.
4. New systems of waste collection and disposal. This type of project explores the feasibility and returns of establishing new systems of waste collection and disposal.
5. Upgrading operation of landfills. In general, the operation of landfills in Georgia is very basic. This type of project explores the feasibility of minimum upgrading to ensure the basic operation of a landfill (e.g. distribution and compaction).
6. Closing existing landfills and establishing new ones. There can be cases when separation measures, such as walls (see project 2) would not be sufficient. In other cases, the landfill could have already reached its full capacity and new ones need to be opened.

The report provides an estimation of collection and disposal fees to ensure a financial internal rate of return (IRR) of either 15% or 20%. All model projects are financed through contributions from municipalities/operators (co-financing), grants and soft/moderate loans. The report presents the resulting fees for different combinations of grants and loans. In most cases, on average, fees are considered to be within the payment capacity of the population.

This report identifies three main types of risks and rates them as follows:

- Technology. Low. The projects do not present sophisticated technologies or operational requirements.
- Payment collection. Medium. It is usually assumed that the population would not pay for waste collection systems. However, there are experiences that show the contrary. The private operator in Rustavi has reached collection rates of 85-93%. Collection rates depend on whether the fee is within the payment capacity of households and, most importantly, on the quality of the service.
- Institutional and regulatory issues. Low to medium. The most important risks comprise (i) regulatory changes and (ii) corruption.

The total size of the project pipeline ranges from USD **2 626 200 to USD 3 646 500**. The report estimates that 2 locations would apply for DFES resources every year. This rather low application rate is based on the pessimistic assumption that the requirement for realistic collection and disposal fees will deter some municipalities. Under these assumptions, the period for disbursement has been estimated at a maximum of 5 years. After this period, an impact assessment should be conducted and a re-estimation of future DFES disbursement should be carried out.

1. INTRODUCTION

Urbanisation and economic development have increased municipal solid waste (MSW) generation worldwide. In the 21st century, the treatment of MSW has become a serious environmental concern and MSW management continues to be an important environmental challenge.

It is only recently that Georgia started to devote attention to its solid waste management problems. The current situation is bad, as waste practices have been at best sub-standard for many years. While legal dumpsites exist, waste often does not reach them because of poor collection systems. Even if waste is collected, it still does not always reach legal disposal sites and is instead discarded in scattered, unregulated dumps. The exact number of legal and illegal dumpsites in Georgia is unknown. In addition to the existence of a large number of unregulated dumpsites, industrial, municipal and hazardous wastes are often disposed of together, creating dangerous, toxic conditions because of the mixing of many different solid and liquid wastes. Improper location of disposal sites and the lack of modern engineering design (liners and collection systems for leachate) are also problems that threaten groundwater supplies, a serious issue for those regions depending almost exclusively on groundwater sources. Simple waste management practices, such as covering wastes, weighing garbage, and fences around dumps are not applied.

While MSW accounts for only 40% of all waste generated in Georgia, it is spread across a larger area with more point sources than industrial waste. The government has indicated that municipal solid waste management is a priority issue in view of its negative impact on public health. The current system, or the lack of it, is an excellent medium for the transmission of diseases. While some efforts are being made to address the problem of unregulated site dumps, this remains an enormous challenge, given the large number of disposal sites, many of which will reach capacity soon and will need to be closed. The government has made certain progress in terms of developing new waste management legislation to regulate the construction and operation of new landfill sites. A crucial aspect, however, will be the establishment of sustainable sources of funding for the sector. Waste tariffs only cover 30-40% of operating costs, leaving no funds available for capital investment. The shortfall is covered with money from the central or local budgets.

Unless measures are taken, problems can only get worse. Waste generation in Georgia will grow, if the Georgian economy continues growing. The composition of waste will also change as incomes increase and people change consumer habits.[46] The problem is particularly serious in cities with limited spare capacity in dumpsites.

[46] A classical example is the increased use of disposable diapers, which can constitute a considerable percentage of total volume disposed.

2. DESCRIPTION OF THE MUNICIPAL SOLID WASTE SECTOR

2.1. Waste Classification and Inventories

Currently, there is no accurate inventory system for waste classification in Georgia. Data on amounts of waste generated, waste types, disposal, and utilisation are scarce and scattered among different agencies. The data are neither digitised nor accessible to different users.[47]

The current waste classification system is based on the Soviet model, which divided waste into five classes according to their level of toxicity. These five classes range from extremely toxic to non-toxic. However, the criteria for the classification of waste types and the definition of "hazardous waste" are sometimes unclear. Currently, Georgia is moving towards the adoption of a new system of data collection and statistical reporting. The transition is being conducted from sector-based to enterprise-based (source-specific) statistics. The State Department for Statistics (SDS) has been charged with this work and is developing a national system of waste classification. The document will have a regulatory status and its application will be mandatory for all users. Under this system, all types of waste (either substances or items) and services related to them will be subject to classification. The source of origin (genesis) and the level of hazard will serve as basic criteria for the classification system. It will cover the whole life cycle of waste management and will be compatible with the National Classification System on Economic Activities, which is in turn based on the European standard NACE.

2.2. Legal Framework

The most important laws on MSW are the following:

- The "Law on Environmental Protection" (1996);
- The "Law on Environmental Permits" (1997);
- The "Law on State Environmental Examination" (1997);
- The "Law on Transit and Import of Wastes into and out of the Territory of Georgia" (1997);
- The "Law on Hazardous Chemical Substances" (1998);
- The "Law on Pesticides and Agrochemicals" (1998); and
- The "Law on Radioactive Safety" (1998).

The Law on Environmental Protection sets the framework in the field of environmental and natural resources protection in Georgia and defines the general objectives of environmental protection as well as the principles, guidelines and mechanisms for their implementation. It also defines rights and duties of citizens and authorities. The law requires that industrial facilities conduct integrated pollution control and monitoring, as well as develop emergency response plans.

The Laws on "Environmental Permits" and on "State Environmental Examination" regulate the process of environmental impact assessment (EIA), State environmental examination (SEE) and the issuance of environmental permits. The Ministry of Environment and Natural Resources Protection (MENRP) of Georgia grants environmental permits provided the applicant meet environmental standards and requirements.

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[47] The Department of Land Resources Protection, Wastes and Chemicals Management under the MENRP recently developed a programme for the inventory of obsolete pesticides and contaminated sites but it was abandoned because of the lack of financing.

The Law on the Transit and Import of Wastes into and out of the Territory of Georgia regulates the movement of “green”, “amber” and “red” wastes through the country. For example, it bans import and transit of hazardous and radioactive wastes in Georgia.

The Law on Hazardous Chemical Substances sets the legal basis for chemicals safety management. It requires registration of hazardous chemicals, licensing of new chemicals and keeping a database on chemical registration, use and storage. In addition, the law contains provisions for the issuing of import/export permits of chemical substances. The Ministry of Health and the MENRP are the responsible authorities for the management of chemical substances.

The Law on Pesticides and Agrochemicals regulates the import, production, transportation, storage and usage of agrochemicals. Among others, it requires the examination and registration of new agrochemicals, updating of a list of allowed chemicals, development of the state catalogue on agrochemicals and setting-up of the state register on agrochemicals by the Ministry of Agriculture and Food or its subordinated bodies. It has banned pesticides listed as hazardous under the Law on Hazardous Substances.

The Law on Radioactive Safety sets the legal framework in the field of nuclear and radioactive safety. It contains provisions for the inventory of radioactive waste and its sources. Specifically, the Nuclear and Radiological Safety Service is responsible for keeping the state register on radioactive waste and its sources, which should include data on existing nuclear and radioactive facilities, quantities of radioactive substances used as feedstock, radioactive substances and waste imported, exported, used or generated, and the locations and technical conditions of their storage and disposal facilities. The owners/operators of nuclear and radioactive facilities are responsible for ensuring that radioactive levels are within legally accepted limits. Along with this, they are responsible for conducting inventories at the source, keeping records on their activities, and annual reporting to the MENRP.

The Law on Waste Management has not yet been adopted in Georgia. A draft law is now under consideration by the Georgian Parliament. It aims to promote the gradual introduction of the European Union (EU) standards and requirements in the field of waste management. It regulates the generation, collection, transport, recycling, reuse, disposal, and rendering harmless of municipal and hazardous wastes. The draft law also establishes waste classification and inventory systems. Its three main objectives are: the application and development of clean production processes to reduce the amount of waste generated; the maximisation of the use of waste for the production of secondary materials or energy; and the provision of modern and safe conditions for the proper treatment and disposal of waste.

The draft law classifies wastes according to their source of origin and their level of toxicity. Based on the source of origin, there are five types of waste: municipal waste, industrial waste, medical waste, agrochemical waste, and biological waste. The law requires keeping a national waste catalogue, using a six-digit trade code according to EC decision 2000/532/EC.[48] The state database on waste should follow the directives of the classification system set in the European Waste Catalogue approved by decision 2000/532/EC in accordance with directives 75/442/EEC and 91/689/EEC. All types of waste listed in the yellow and red lists of the EU directive 259/93/EEC are classified as hazardous.

The draft Law on Waste Management does not designate one specific management authority; rather, it requires the establishment of a steering committee under the MENRP for the coordination of waste management activities for all types of waste.

[48] Before the rule is adopted, wastes should be identified in accordance with the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal, and EU Directive 259/93/EEC.

Other regulations and codes

The current standards that regulate the design/operation of landfills and waste processing facilities are based on regulations adopted in the 1970s/1980s. These standards are outdated and not always clear. For example, landfill building codes and sanitary standards can be interpreted differently resulting in improperly designed dumpsites, transfer stations and other facilities and unrealistic construction and operation budgets. It is hoped that new guidelines will be introduced soon. Some of them, such as the "environmental passport system", have already been in force since 1994.

2.3. Institutional Setting

Responsibilities for waste management are not always clearly defined and in fact are fragmented. This has led to confusion among different levels of government and waste management firms, duplication of activities and the neglect of others. Several agencies are involved in waste and chemicals management in Georgia, yet there is little co-operation among them. Data collected are seldom shared or exchanged.

The MENRP is responsible for developing and implementing national waste management policies, strategies and regulatory documents, as well as for enforcing existing norms and standards for environmentally sound disposal and treatment of industrial and municipal wastes. It is in charge of coordinating the activities of different ministries and local self-governing bodies, issuing permits to large industrial enterprises, collecting payments for waste disposal, issuing licences for the transboundary movement of waste and promoting international co-operation.

The Department of Land Resources Protection and Waste Management at the MENRP consists of three divisions, one in charge of land protection, and the other two of waste and chemicals management. The department gathers information on contaminated sites, and on industrial and municipal wastes and chemicals. Its main sources of information on land contamination are local authorities, MENRP labs (land contamination by pollution sources) and Hydromet (the State Department of Hydrometeorology), which provides data on ambient pollution. The department also plays an important role in issuing permits and monitoring enterprises to ensure that they are in compliance with existing regulations.

The regional departments of the MENRP collect information on industrial wastes. They use standard questionnaires, which are prepared by the Department of Land Resources Protection and Waste Management, to be filled out by owners/operators of industrial facilities. The local offices of the MENRP, along with municipalities, are the main sources of information on municipal wastes. At present there are no legally binding reporting requirements for waste, and existing data are not entered in computers but stored in paper formats.

Municipal and local authorities are responsible for the collection and disposal of MSW and play an important role in establishing and running waste disposal sites and facilities for processing both municipal and industrial waste.

The Nuclear and Radiation Safety Service coordinates and carries out an inventory of radiation sources and radioactive waste at former Soviet military bases. It has a staff of 10 people.

The Ministry of Economy, Industry and Trade[49] is responsible for licensing export and import of industrial waste.

[49] Transformed into the Ministry of Economic Development.

The Ministry of Labor, Health and Social Affairs is responsible for setting and enforcing sanitary-hygiene standards, including soil and food product standards. It is also responsible for setting-up and operating the state register on hazardous substances.

The Ministry of Agriculture and Food is responsible for the state inventory of agrochemicals, development of agrochemicals catalogues and approval of the list of permitted agrochemicals.

The State Department for Statistics is responsible for defining and operating the national system of classification, including waste classification.

The State Department of Hydrometeorology, through the National Center for Environmental Monitoring, is responsible for the regular collection of data on soil contamination in agricultural and industrial areas. While the Center has an analytical laboratory for soil analyses, soil quality monitoring is not currently conducted due to the lack of financial resources.

2.4. Management of Waste Collection and Disposal Systems

Waste collection and disposal systems in Georgia are either state managed or have combined state and private management. The biggest settlements – Tbilisi, Kutaisi, Rustavi and Poti – have a mixed (state and private) management system. On the other hand, Batumi, Zugdidi, Gori, Zestaponi and Kobuleti have the municipality managing waste collection and disposal. Below is a description of the characteristics of the mixed management systems used in the cities of Poti and Rustavi.

Poti. The Ministry of Infrastructure of Georgia defines the general technical policy in Georgia for the collection and treatment of solid waste. At the local level, this general policy is fine-tuned by the Environmental Department, which sets the environmental guidelines for the collection, transportation and disposal of solid waste in Poti. The Sanitary Cleaning and Greenery Department (SCGD), which works under the Environmental Department, is responsible for: (1) collection, transport and disposal of solid waste from households and enterprises; (2) cleaning and sweeping of streets and pavements, collection of street waste, and its transport and disposal; (3) exploitation of the landfill site; and (4) management of waste disposal vehicles and equipment. The SCGD of Poti controls the largest part of the city and the landfill site, while the Port of Poti controls the harbour area and some streets around the port, and the firm Fumigator collects the waste from ships. However, this arrangement leaves sections of Poti with no waste disposal service whatsoever.

In October 2002, the SCGD of Poti signed an agreement with "Alka Ltd.", under which this company was to provide services for the streets of Agmashenebeli, Rustaveli, Jugashvili, 9 April, Akaki and Guria, located in the city centre, and for the area surrounding the market as well. This change in the waste collection and disposal system of the area was considered to be appropriate and an improvement, especially because the area has mostly tall buildings and a population density that is higher compared with other areas. Thus, the achievement of desired results was possible here in a cost-effective way from an economic and environmental point of view. From May 2003, this function was transferred to "Poti-Kalakservice Ltd." set up on the basis of "Alka Ltd.".

The Cleaning Department handles only main streets and squares, where people dispose of their waste in containers placed on the pavement. The trucks collect the waste between 6.30 and 8.00 in the morning, emptying the containers whether they are full, half full or empty.

The population of Poti does not have money to pay the Cleaning Department; the Cleaning Department does not have a budget, and the City Council cannot raise the budget, so the population, especially the residents of the high-rise buildings near the river, throw their waste over the concrete wall alongside the river.

Rustavi. Until 2003, there was only one organisation, the Sanitary Cleaning Service (SCS) of the Rustavi Municipality, that collected waste in Rustavi. The SCS controlled waste disposal of the whole city.

In 2003, the municipality signed an agreement with a private company “Avtomobili-2003 Ltd.”, which operates 9 micro districts of the city, where predominantly 9-storey buildings are to be found (in total 1 200 entrances). These buildings are equipped with bins systems. The company also operates one micro district that has mainly 5-storey buildings. The residents of these buildings take out the garbage into the iron bins placed outside their houses. The company was supplied with 12 completely obsolete Soviet-made trucks.

The remaining part of the city (approximately 60 000 inhabitants) is still served by the SCS. The operating area includes about 200 entrances with a bin system. The remaining 5-storey buildings have been transferred to the bin system and are supplied with metal containers that have a capacity of 2 m^3.

Currently, there is sufficient capacity to increase the service, with regard to both the amount of waste collected and the area served.

According to SCS information (based on tentative assessments), the total amount of solid waste dumped in the landfill site is about 81 000 m^3, which corresponds to a waste generation rate of 0.7 m^3/(capita/year). About 75-80% of the waste is dumped, and 20-25% vanishes into the ground and the river. The current estimate of the city’s waste production is about 100 000 - 110 000 m^3 (0.87-0,93 m^3/capita/year).

2.5. Government Priorities for Municipal Solid Waste

The priorities are as follows:

- Development of comprehensive waste management plans for big cities and regions;
- Creation and introduction of a system of differentiated tariffs to cover waste collection and disposal operations and investment in upgrading waste management infrastructure;
- Development of guidelines and standards for the construction and operation of landfill sites and recycling plants;
- Introduction of waste source separation and collection systems in cities and regions;
- Construction of facilities to manufacture waste containers for MSW collection;
- Design and construction of recycling plants with the objective of an 80% recovery rate of secondary materials, such as metal, glass, paper, plastics, textiles, and organic matter;
- Application of technologies for waste reduction at enterprises;
- Improvement of data collection on waste generation (weight, volume, physical and chemical composition), including recyclable materials; and
- Improvement of the transparency of the tariff collection system and minimisation of corruption in the sector.

2.6. Waste Generation Rates

In 1989, the population of Georgia numbered about 5.4 million, but decreased to 4.6 million by 2002.[50] At present, 52% of the population lives in urban areas, and 48% in rural areas. According to our own estimations, in 2003 the urban population produced a total of about 750 000 tonnes of solid waste. About 590 000 tonnes of this waste are disposed of in municipal disposal sites.

The volume of waste generation has changed from year to year, depending on economic performance and the supply of utilities, such as gas, water, sewerage and heating. Per capita waste generation rates are far below those in developed countries where income and consumption levels are higher. In addition to lower per capita waste generation rates, Georgia also produces less MSW per USD 1 000 GDP than other countries. This is due to its undeveloped economy and the low level of consumption.

2.7. Waste Composition

Accurate data on the composition of MSW in Georgian cities are not available, except for data from the World Bank's "Tbilisi Solid Waste Management Project". Based on these data, the largest components of MSW are food waste and mixed paper (paper/cardboard), followed by textiles, metals, wood and glass. Together, these items represent 89% of all waste. Table 1 presents the composition of MSW in Tbilisi.

Table 1: Composition of MSW (Tbilisi)

Component	Share, %
Food	39
Mixed Paper	34
Metals	5
Textiles	5
Glass	3
Wood	3
Plastics	2
Leather	1
Stones	1
Other	7

Source: World Bank.

2.8. Waste Disposal Sites

The primary method of waste disposal in Georgia is landfilling. The soil type and water tables were not always taken into account when determining the location of landfills. Many landfills lack liners and leachate collection control systems. Groundwater contamination from landfill leachate is of concern at a number of sites. Some waste sites have been identified as posing a serious threat to the environment, for example, the one at Poti, which is located right on the bank of the river Rioni without even the most basic precautions to avoid contamination of international water bodies.

In addition to being poorly designed from an engineering perspective, many old landfill sites do not operate in accordance with basic waste management standards. As a result of the lack of machinery, waste is not compacted, covered or insulated. There is no removal of leachate from wells and water sampling. Waste is not weighed when it arrives at dumpsites, nor is it categorised according to type (e.g. industrial, municipal, hazardous).

[50] Migration due to economic crisis and civil war accounts for this decrease.

3. BENEFITS FROM IMPROVED MUNICIPAL SOLID WASTE MANAGEMENT SYSTEMS

What follows is a description of the main national and international benefits that could be achieved from improving municipal solid waste management systems (MSWMS) in Georgia.

Decreased pollution of international water bodies

The final destination of a large part of waste is the Black Sea and the Kura River basin. First, landfills are sometimes built on the edge of watercourses. Storms and changes in the water level periodically wash out significant amounts of waste. In addition, one of the most serious problems is the illegal disposal of waste. Traditional places for this practice are isolated locations along the coast and river margins.

Figure 1. Pollution of International Waters - Landfill in the City of Poti

Decreased groundwater contamination

The most significant point sources of groundwater contaminants are municipal landfills and industrial waste disposal sites. When either of these is found in or near sand and gravel aquifers, the potential for widespread contamination is the greatest. Some landfills have been] located over aquifers used as sources of drinking water and within 1 km of a water supply well.

Heavy metals and toxic organic chemicals that originate in the decomposition of municipal waste can contaminate groundwater in the vicinity of landfills.[51] Surface water and rainwater leach soluble hazardous chemicals that penetrate into the groundwater used by the local population. Contaminants that may enter groundwater also include bacteria, viruses, detergents, and household cleaning materials. These can create serious contamination problems. It has often been assumed that contaminants left on or under the ground will stay there. This is not always the case. Groundwater often spreads the effects of dumps and spills far beyond the site of the original contamination. Groundwater contamination is extremely difficult, and sometimes impossible, to clean up.

In Georgia, pollution of surface water by groundwater is probably at least as serious as the contamination of groundwater supplies. Preventing contamination in the first place is by far the most practical solution to the problem. This can be accomplished by the adoption of effective waste collection and disposal systems.

[51] Landfills pollutants of concern: 1,4-Dioxane, 1234678-HPCDD, 2-Butanone, 2-Propanone, 4-Methyl-2-Pentanone, Alpha-Terpineol, Ammonia as Nitrogen, Arsenic, Barium, Benzoic Acid, Boron, Chromium, Chromium (Hexavalent), Dichlorprop, Disulfoton, Hexanoic Acid, MCPA, MCPP, Methylene Chloride, Molybdenum, N, N-Dimethylformamide, O-Cresol, OCDD, P-Cresol, Phenol, Silicon, Strontium, Titanium, Toluene, Tripropyleneglycol Methyl Ether, Zinc.

Pests
Flies and mosquitoes are best controlled by daily covering of the solid waste along with the elimination of any open standing water. Rats can be a problem at open dumps but the use of covers, which ensures that all food waste is buried, eliminates rat problems at sanitary landfills.

Scavenging
Scavenging is the uncontrolled picking of waste to recover useful items, as contrasted to salvaging, which is the controlled separation of recoverable items. While recycling may be desirable, scavenging in landfills is not. People, doing this, have been injured, sometimes fatally, while searching the waste. It is also a serious health risk issue for those involved in the activity and for those living in the proximity.

Aesthetics
Making an urban site pleasant to look at, while largely cosmetic, is not a frivolous benefit. Aesthetics means proper waste collection in urban settlements and litter control at dumpsites. In turn, the change in aesthetics for the better is an important incentive for the population to improve their own waste disposal practices (e.g. no littering) and payment collection rates.

Fires and odours
Odours are best controlled by a daily cover as well as by adequate compaction. Daily covers also form cells that reduce the ability of fires to spread throughout a landfill.

Reduced emission of greenhouse gases
The management of municipal solid waste presents many opportunities for greenhouse gas emission reductions. Source reduction and recycling can reduce emissions at the manufacturing stage, increase forest carbon storage, and avoid landfill methane emissions. Combustion of waste allows energy recovery to displace fossil fuel-generated electricity from utilities. Diverting organic materials from landfills also reduces methane emissions.

4. MODEL PROJECTS FOR MUNICIPAL SOLID WASTE MANAGEMENT

This report presents several model projects. These model projects constitute good examples of affordable remedial actions aimed at decreasing pollution of international water bodies and risks to public health.

All data used in the economic and financial analysis of the model projects come from the city of Poti (40 000 inhabitants). This is due to the fact that Poti is a medium-size town that best exemplifies common problems affecting MSWMS in Georgia. All model projects can be easily scaled up or down according to the particular characteristics of other communities. This will be done later in the report to present the estimated size of the project pipeline.

4.1. Introduction

Poti presents problems that are common to small and medium size settlements along the coastal Black Sea area and the Kura River basin. Specifically:

- No new waste disposal site is under consideration, despite the fact that the present location could have not been worse (on the edge of the River Rioni).
- Because the river Rioni regularly floods the landfill site, a significant amount of solid waste ends up in the Black Sea. Garbage can be seen everywhere along the shore, as far as many kilometres south of Poti.
- The present practice of legal and illegal dumping is a major health hazard for the population and violates the Black Sea Convention, which the Georgian Government is part of. Pigs and cows regularly search for food in the landfill site, which is not fenced off.
- Solid waste is dumped illegally in various parts of the town, whenever the "official" site is not accessible for trucks. Illegal dumping also occurs along the river and the Black Sea coast.
- Little knowledge of, and skills in, modern methods of integrated water management, as well as solid waste disposal techniques are available in the city.

4.2. Strategies for Improvement of MSWM

The following are general strategies that apply to all MSWM model projects in all locations:

Improperly located landfills
A major problem in cities such as Poti and Batumi is the location of landfills right on the edge of international water bodies. These landfills lack separation walls and lining, and constitute a major point of pollution as well as a health risk problem.

The strategy for dealing with improperly located landfill sites can comprise (i) protection measures, such as the construction of separating walls, and (ii) closing the landfill and establishing a new one. Whether protection measures or the closure of the landfill is the chosen option will depend on issues of groundwater contamination with regard to the opportunity cost of resources invested in closing the existing landfill and the opening of a new one.

Illegal dumpsites
In the short term, an important objective is to tackle the problem of illegal dumpsites, especially those close to watercourses and the coastal belt. Before proper landfills can be made operational, an intermediate alternative is to place "skip" containers with a volume of 5 m^3 in those locations where illegal dumping is known to take place. At least once a week, a collection truck would pick up these containers and transport them to the landfill site. These temporarily accepted "illegal" dumpsites would be removed after about one year and fixed collection points would be established instead. An alternative to these containers is refuse bags, possibly in combination with wheeled bins (the so-called mini-containers).

Waste collection at buildings[52]
The original system of waste disposal in buildings was a central refuse chute. Garbage would fall to the bottom floor where there was a collection room. At present, the lack of maintenance and erratic waste collection have resulted in the saturation or non-operation of many of these systems. In many buildings, people just dispose of garbage outside in the nearest place around.

A solution to non-operational refuse chutes is the use of wheeled containers. The preferred alternative would be to put a 1 000 - 1 600 litre container under the refuse chute. For places having a high rate of waste generation, it is also possible to put a 5 m^3 "skip" container.

[52] This refers to buildings of 5 floors or more.

The collection of this type of container should be done with the help of a lifting system similar to the one on current collection trucks. Depending on the lifting capacity, it would be possible to update the lifting system and collect containers having a volume of 120, 240 and maybe 360 litres. This is a short-term solution. For the longer term, it is advisable to invest in collection trucks that have crushing and compacting capacity.

Private households
Collecting waste from buildings and a cluster of buildings is relatively simple and cost-effective. Most urban settlements, however, have large sections of private houses. This poses problems as it increases the cost of collection.

The solution is to invest in collection trucks with mini container lifting systems and to set up regular routes along the households. Mini containers are plastic or steel containers having a volume of 120, 240 or 360 litres, two little wheels and a cover on top. A mini container costs about USD 50 a piece and a collection vehicle, USD 100 000. For a town of the type of Poti, this would mean an investment of approximately USD 150 000 (3 000 containers) and USD 200 000 (2 trucks). This results in a total investment of USD 350 000.

Paper and cardboard
To introduce a "paper route" and have the refuse collection truck collect all paper at the house holdings, enterprises, schools etc. on a monthly basis, will be a solution.

Waste from commercial sources
Placing containers at enterprises and charging them a differentiated fee for collection, transport and disposal can help.

Improving tariff and collection rates
Financial sustainability is at the heart of a viable MSWMS. Poti, with 47 000 inhabitants, generates about 58 000 m^3 of garbage per year.[53] The Municipal Authority is supposed to charge fees and cover the total costs of the waste disposal system. However, a significant subsidy is involved (80% of costs). The tariff for domestic collections is GEL 3.2/m^3 (USD 1.6/m^3) or GEL 0.2/capita/month (USD 0.1/capita/month). The tariff for collection and disposal from commercial organisations is GEL 4.2/m^3 (USD 2.1/m^3). These rates do not provide for sufficient revenues.

It is crucial that municipalities charge fees that cover the operational and investment costs of MSWM. This is not impossible to do. The experience from Rustavi shows that when there is proper collection, the population is willing to pay increased rates. Some sections of Rustavi that are under private MSW management have collection rates of between 85-93%.

4.3. Selected Projects for Improved MSWM

This section will present different project components for improved MSWM in Georgia. Below is a description of the characteristics and assumptions that are common to these projects.

- Before implementation of project components begin, DFES resources would be invested in the preparation of an action plan for MSWM for the municipality that applies for support. The action plan

[53] However, the municipality collects just 35 000 m^3 or 60 % of the total amount of solid waste generated. The remainder is dumped illegally in the river, the Black Sea or elsewhere.

would cover a period of 15 years. The document would fine-tune the measures to be taken and the sources of financing.

- International prices for equipment were used for the economic and financial calculations. Border prices have been estimated, excluding taxes and import duties. Local labour costs are used for the analysis.
- The financing scheme comprises a combination of grant and soft or moderate loan to the city municipality, or through the municipality to the private company working under agreement with the municipality. The report explores several combinations of grant and loan shares for each type of project.
- All projects presented, including capital and labour needs, come from Poti. This allows us to provide concrete examples of the economic and financial viability of the projects.

For the economic analysis, the following assumptions apply:

- Loan interest rate recovery starts in year zero (the year before the new system is put into operation);
- Annually, the loan interest rate is covered from the average value of that year and the previous year corresponding residual debt; and
- 7.5% has been taken as a depreciation rate.

All current taxes in force in Georgia are taken into account and comprise:

- Value added tax (VAT) – 20% of taxable turnover;
- Tax on property – 1% of book value;
- Tax on economic activities (enterprise tax) – at most 1% of pre-VAT revenues; and
- Tax on profit - 20 % of taxable profit.

Fees and the composition of the share of grants and loans in financing have been set to attain financial returns of 15 or 20 %. It is also assumed that:

- The loan is soft, if the repayment period = 5 years and the interest rate = 4%.
- The loan is moderate, if the repayment period = 5 years and the interest rate =12%.

Project 1: Fencing of landfills

The existing landfill in Poti, as well as in many other towns in Georgia, is in a very unsatisfactory condition. The territory around the landfill (at a distance of 2-3 km) is covered with trash and plastics. Everywhere there is a strong smell that makes living conditions for nearby residents very unpleasant.

The landfill site is not fenced off, nor does it have a green protection line. Pollutants are transported towards the residential area, causing air pollution and threatening the health of the local population. Pigs and cows can be regularly seen searching for food on the landfill.

Fencing of the landfill territory, and creating a green buffer zone separating it from the residential area, would keep the dispersion of garbage and pollutants by wind to a minimum and partially reduce odour. These measures should be considered as a priority action. The buffer between the landfill and the residential area should be at least 50 m wide and, if possible, wider. The costs of landfill fencing and the establishment of a green line are presented in Table 2 below.

Table 2: Landfill Fencing and Planting Costs

N		Unit	Number of Units	Cost (USD)	
				Per Unit	Total
	Fencing				
1	*Fence*	M	900	2	1 800
2	*Iron poles*	Piece	600	4	2 400
3	*Cement*	Tonne	30	100	3 000
4	*Sand and gravel*	Tonne	100	30	3 000
5	*Iron gate*	Piece	2	750	1 500
6	*Wage fund (including taxes)*	Worker	12	520	6 240
7	*Covering and compacting*				2 600
	Total fencing				**20 540**
	Planting green line				
1	*Trees*		300	3	900
2	*Bushes*		900	2,5	2 250
3	*Transportation*				90
4	*Wage fund (including taxes)*	Worker	6	160	960
	Total planting				**4 200**
Total fencing and planting					**24 740**

Source: Own estimates.

These measures could be financed by the local budget of the city, which is an unlikely option for many municipalities, or be added to collection fees. The estimated increases in fees are shown in Table 3. There is the assumption that only 20% of investment would be provided by the municipality and that the share of the DFES grant would vary between 0 and 80%.

According to Table 3, the maximum increase in fees with regard to the existing fee would be USD 0.011/capita/month, or up to 12% of the current rate (depending on the share of grant and loan). We estimate that an optimal combination of grant and loan would be the one that adds no more than 5-6% to the current fee.

Table 3: Increase in Fees According to Different Combinations of Grant and Loan (USD)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fee (IRR=15%) (USD/month)	0.01	0.008	0.006	0.005	0.003
5	Increase in fee (IRR=20%) (USD/month)	0.01	0.011	0.007	0.005	0.003
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fee (IRR=15%) (USD/month)	0.011	0.009	0.007	0.005	0.003
5	Increase in fee (IRR=20%) (USD/month)	0.012	0.009	0.007	0.005	0.003

Project 2: Separation of landfills from river courses and coastal waters

The location of a landfill right on the edge of a water body is not unusual in Georgia. Batumi has its own landfill on the border of the river Chorokhi. Poti has its landfill on the edge of the river Rioni. There are many illegal and legal disposal sites along the banks of rivers. Waste is regularly washed out into watercourses.

This model project will take the example of Poti, from which data have been collected. These results can be easily extrapolated to other locations. The existing landfill is located 7 km north-east of Poti on the embankment of the river Rioni. The basic requirements of sanitary zoning are not observed, in particular, the one that sets the minimum distance between the river and a landfill at 300 m[54]. The landfill is poorly managed. It is served by only one bulldozer which, due to the lack of maintenance, operates only a few days a month and performs a simple operation consisting of spreading and compacting the garbage.

The river Rioni regularly washes out the landfill. In addition, and according to information by local residents, the river has cut away about 3-4 m of the landfill a year, depending on weather conditions. The opening of a new landfill is on the agenda, but the lack of financing has made this difficult. Until a long-term solution is found, the recommendation is to construct a concrete wall along the whole bank of the landfill. The estimated price is given in Table 4[55].

Table 4: Concrete Wall Construction Costs (in USD)

Item	Cost
Materials: cement, sand, gravel, armature – steel concrete reinforcement	170 000
Rent for building machinery (structural, building engineering)	25 000
Wage fund and taxes	20 000
Total	215 000

Source: Own estimates.

At present, the municipality is unable to allocate USD 215 000, but it may be able to mobilise 20% of the construction expenses. In this case, the remaining USD 172 000 could be mobilised by means of a grant and/or soft loan. The estimated increases in fees for different combinations of grants and loans are given in Table 5.

[54] Another basic requirement is to have a distance of at least 500 m between the urban area and the landfill. In Poti this is also not observed. In fact, the landfill represents an extension of the city, as it begins from the yard of the last house.

[55] The price of high-quality concrete is estimated to be about USD 90 - 100/m^3. The estimated length is 400 m, height is 8 m, and width is 0.75 m.

Table 5: Increases in Fees for Different Combinations of Grants and Loans (USD)

Soft Loan (5 Years, Interest = 4 %)				
1	Grant (%)	0	40	80
2	Soft loan (%)	80	40	0
3	Increase in fees (IRR=15%) (USD/capita/month)	7.6	3.9	0
4	Increase in fees (IRR=20%) (USD/capita/month)	0.08	0.041	0
Moderate Loan (5 Years, Interest = 12 %)				
1	Grant (%)	0	40	80
2	Moderate loan (%)	80	40	0
3	Increase in fees (IRR=15%) (USD/capita/month)	0.091	0.046	0
4	Increase in fees (IRR=20%) (USD/capita/month)	0.096	0.049	0

The increase in fees in the absence of grant components is 80% of the existing fee. This is probably not a viable option. It would be better to finance this project with a higher grant share.

Using the same values of fees as in Table 5, we can calculate the economic and financial IRR. Table 6 shows that economic IRR varies in the range of 45-75% and significantly exceeds the financial IRR.

Table 6: Economic and Financial IRR

Soft Loan (5 Years, Interest = 4 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	49.5 / 15	56.4 / 15
Economic IRR (%) / Financial IRR	64.7 / 20	75.6 / 20
Moderate Loan (5 Years, Interest = 12 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	44.4 / 15	47.4 / 15
Economic IRR (%) / Financial IRR	55.4 / 20	63.1 / 20

Project 3: Expansion of the existing waste collection system

Many of the waste collection systems only partially cover urban settlements. That is, it is not rare to see towns or cities with waste collection systems that leave large sections with no or limited service.

Poti is not an exception. “Poti-Kalakservice Ltd.” operates in the central part of the city, while the municipality partially covers the rest. The private company provides better service than the municipality. The number of residents living in the section serviced by “Poti-Kalakservice Ltd” represents about 17-18% of the total Poti population, or nearly 8 000 - 8 500 inhabitants. There are plans to expand the coverage of “Poti-Kalakservice Ltd.” to all buildings for a total of 16 - 17 000 inhabitants.[56] This expanded service would require an additional collection truck and about 80 - 90 new containers, for a total investment of USD 40 500.

[56] This refers to buildings with 5 or more floors.

Table 7: System Expansion - Investment Costs (in USD)

Item	Number	Unit Price	Cost
Containers	90	250	22 500
New truck	1	18 000	18 000
Total			**40 500**

Source: Own estimates.

To calculate operation and maintenance (O&M) costs, it is assumed that waste is collected daily. This requires 3 truck drivers and 6 auxiliary workers. The results are shown in Table 8.

Table 8: Annual Operation and Maintenance Costs (in USD)

	Item	Unit	Number of Units	Cost per Unit	Total Costs
1	Salary fund: *Administration*	Person	3	1 500 (=125 x 12)	4 500
2	*Drivers*	Person	3	1 500 (=125 x 12)	4 500
3	*Driver assistants*	Person	6	1 200 (=100 x 12)	7 200
4	*Wage fund in total*	Person	12		*16 200*
5	Taxes (31% of wage fund)				5 022
6	Gasoline	Litre	10 000	0,5	5 000
7	Repair of trucks, spear parts, etc.				7 500
Total					**33 722**

Source: Own estimates.

It is assumed that the operating company or municipality would mobilise it own capital for expanding the service and contribute 20% of total investment. The remaining 80% would be covered partly by a grant and partly by a loan.

This report considers 2 options: (i) a five-year loan of 4% interest, and (ii) a five-year loan of 12% interest. Table 9 presents the calculations for different ratios of grant and loan. Investment is recovered in 10 years.

Table 9: Calculated Tariffs for Various IRR (in USD Capita/Month)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Tariff (IRR=15 %)	0.260	0.252	0.244	0.235	0.227
5	Tariff (IRR=20 %)	0.264	0.255	0.247	0.238	0.229
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	0.267	0.257	0.247	0.237	0.227
5	Fees (IRR=20 %)	0.272	0.261	0.250	0.239	0.229

Table 9 shows that there are relatively small differences in fees as the grant share goes from 0 to 80%. This reflects the fact that loan-servicing expenses are smaller than operational expenses. Table 10 presents the results for a recovery period of 5 years.

Table 10: Calculated Tariffs for Various IRR (in USD/Capita/Month)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	0.279	0.268	0.256	0.244	0.233
5	Fees (IRR=20 %)	0.281	0.270	0.258	0.246	0.235
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	0.288	0.276	0.262	0.247	0.233
5	Fees (IRR=20 %)	0.291	0.277	0.263	0.249	0.235

Again, Table 10 shows that there is a relatively minor increase in fees as the grant share diminishes. However, these differences do matter for the population and they add up as more and more projects are implemented.[57] As long as DFES resources allow it, it would be best to choose options where the grant share is the greatest.

The economic and financial IRR have been calculated using the fees from Table 11, which shows that the values of the economic IRR vary in the range of 140-155% and significantly exceed the values of the financial IRR.

Table 11: Estimated Economic IRR and its Comparison with Financial IRR

Soft Loan (5 Years, Interest = 4 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	150 / 15	142 / 15
Economic IRR (%) / Financial IRR	155 / 20	146 / 20
Moderate Loan (5 Years, Interest = 12 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	147 / 15	141 / 15
Economic IRR (%) / Financial IRR	152 / 20	140 / 20

Project 4: New system of waste collection and disposal

Rather than expanding an existing waste collection system, this project explores the feasibility and returns of establishing a new system of waste collection and disposal for a town of 45 000 people. Two scenarios are considered:

1. Existing situation (Scenario 1). This assumes unchanged population levels and unchanged rates of waste generation per capita;

[57] This means that the fees increase as the system is expanded, the wall of the landfill is constructed, containers are placed in illegal dumping sites, and so on and so forth.

2. Increase in population and waste generation rates (Scenario 2). In this scenario, there is a 2% increase in the population to reach 55 000, and the amount of waste generated per capita increases to reach 1.2 m^3/capita/year.

For these two versions, the following assumptions hold:

- The number of containers depends on population density;
- The number of daily trips to collect waste depends on the distance to the landfill and on the time necessary for emptying containers into the truck; and
- The number of drivers is calculated on the assumption that each driver works 5 days a week and 11 months a year. Each driver has an assistant.

The parameters for the new system of waste collection and disposal are presented in Table 12.

Table 12: Parameters of the New System of Waste Collection

N	Parameters	Symbol / Formula	Value		Unit
			Scenario I	Scenario II	
1	Population	P1	47 .000	55 .000	Inhabitant
2	Full unloading of containers per day	P2	**0.50**	**0.50**	
	Full unloading of containers per month	=P3/12	**15.21**	**15.21**	
3	Full unloading of containers per year	P3=P2 x 365	183	183	
4	Number of containers per 1 000 people	P4=1000/(P4/P8)/P11	6.18	8.73	Piece
5	Number of containers needed	P5=P1/1000 x P4	291	480	Piece
6	Containers storage capacity	P6	**1.10**	**1.10**	m^3
7	Containers storage capacity as a whole	P7=P6 x P5	319.6	528.0	m^3
8	Per capita waste generation rate	P8	**0.85**	**1.20**	kg/capita/day
9	Waste density	P9	**0.25**	**0.25**	1 000 kg/m^3
10	Per capita waste generation rate	P10=P8/P9/1000	0.00340	0.00480	m^3/capita/day
11	Per capita waste generation rate	P11=P10 x 365	1.24	1.75	m^3/capita/year
12	Annual MSW generated	P12=P1 x P11	58.327	96.360	m^3
13	Truck body space	P13	**7.3**	**7.3**	m^3
14	Number of containers per truck	P14=P13/P6	6.6	6.6	Containers
15	Containers unloaded per day	P15=P5 x P2	145	240	Piece
16	Total amount of hauls				
17	*Per day*	P16=P15/P14	22	36	Hauls
18	*On average per month*	P17=P16 x 365 / 12	670	1 108	Hauls
19	*On average per year*	P18=P17 x 12	8.045	13.291	Hauls
20	Number of trucks	P19	**8**	**13**	Truck
21	Number of hauls per truck				
22	*On average per day (B14/B17)*	P20=P16/P19	2.76	2.80	Hauls
23	*On average per month (B15/B17)*	P21=P17/P19	84	85	Hauls
24	*On average per year (B16/B17)*	P22=P18/P19	1 006	1 022	Hauls
25	Number of working days per year	P23=365 x 11/12 x 5/7	239	239	Day/year
26	Number of hauls per driver	P24=P20 x P23	658	669	Hauls
27	Number of drivers	P25=P18/P24	12	19	Person
28	Number of driver assistants	P26=P25	12	19	Person
29	Normal (mean) length of haul	P27	**18.0**	**18.0**	km
30	Annual mileage	P28=P18 x P27	144.812	239.239	km
31	Empty run	P29=P28 x 0.1	14.481	23.924	km
32	Fuel consumption per 1 km	P30	**0.25**	**0.25**	Litre/km
33	Fuel consumption in total	P31 x (P28+P29) x P30	39 823	65 791	Litre

Source: Own estimates.

The increase in population and in production of waste per capita translates into an increase in investment costs. Table 13 presents the equipment costs. The prices are for second-hand equipment. “Kalakservice Ltd.” has proved that western second-hand equipment is quite effective and substantially cheaper than new units.

Table 13: Equipment Costs (in USD)

	Scenario I			Scenario II		
New containers	291	200	58 200	480	200	96 000
New trucks	8	30 000	240 000	13	30 000	390 000
Waste harvester machine	1	30 000	30 000	1	30 000	30 000
Total			**328 200**			**516 000**

Source: Own estimates.

The increase in population and in production of waste per capita translates also into an increase in O&M costs, which increase from USD 80 000 to USD 141 000, as shown in Table 14 below.

Table 14: Operation and Maintenance Costs (USD)

	Collection and Landfilling Costs	Scenario I			Scenario II		
		Unit Value	Number	Total	Unit Value	Number	USD
1	Wages: *Administration*	30	14	5 040	50	14	8 400
2	*Caretakers*	25	67	20 100	40	67	32 160
3	*Technicians*	40	4	1 920	50	4	2 400
4	*Drivers*	50	12	7 200	75	19	17 100
5	*Driver assistants*	35	12	5 040	50	19	11 400
6	*Wage fund in total*		*109*	*39 300*		*123*	*71 460*
7	Taxes (31% of wage fund)			12 183			22 153
8	Uniforms	50	26	1 300	50	26	1 300
9	Brooms	2	360	720	2	360	720
10	Trowels	7	67	469	7	67	469
12	Gasoline	0.5	39 823	19 912	0.6	65 791	39 474
13	Maintenance costs (repair of trucks, etc.)			11 000			11 000
	Total			**79 884**			**141 576**

Source: Own estimates.

The financial calculations in Table 15 use fees that assure a financial IRR of either 15% or 20%. Tables 16 and 17 present the results. It can be seen that fees in Scenario 2 are 1.6 times greater than in Scenario 1, and exceed the current fees in Poti. The impact of the grant share is noticeable. With a 0% grant share, the fee is 1.4 to 1.5 times greater than when the share is 80%.

Table 15: Fees for Scenario 1 - (USD/Capita/Month)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Tariff (IRR=15 %)	29.2	27.1	25.0	22.9	20.8
5	Tariff (IRR=20 %)	30.1	27.8	25.6	23.3	21.1
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	30.6	28.0	25.5	23.0	20.5
5	Fees (IRR=20 %)	31.9	29.2	26.5	23.8	21.1

We have calculated the economic IRR for the values of fees that assure a financial IRR of 15% or 20%. As can be seen in Table 16, the economic IRR varies in the range of 45-55% and significantly exceeds the financial IRR.

Table 16: Estimated Economic and Financial IRR - Scenario 1

Soft Loan (5 Years, Interest = 4 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	48.8 / 15	52.1 / 15
Economic IRR (%) / Financial IRR	54.7 / 20	56.7 / 20
Moderate Loan (5 Years, Interest = 12 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	44.5 / 15	47.8 / 15
Economic IRR (%) / Financial IRR	52.4 / 20	55.1 / 20

Table 17 shows the different fees required for Scenario 2 as the share of grant and loan varies.

Table 17: Fees for Scenario 2 - (USD/Capita/Month)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	0.457	0.426	0.395	0.364	0.333
5	Fees (IRR=20 %)	0.476	0.442	0.409	0.376	0.343
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Fees (IRR=15 %)	0.481	0.444	0.407	0.370	0.333
5	Fees (IRR=20 %)	0.504	0.463	0.423	0.383	0.343

Table 18 shows the economic IRR using the fees estimated in Table 17. The economic IRR varies in the range of 42-53% and significantly exceeds the financial IRR. The values of the IRR are approximately equal to the values obtained for Version 1 of the project.

Table 18: Estimated Economic and Financial IRR - Scenario 2

Soft Loan (5 Years, Interest = 4 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	43.9 / 15	46.8 / 15
Economic IRR (%) / Financial IRR	51.6 / 20	53.1 / 20
Moderate Loan (5 Years, Interest = 12 %)		
Grant (%)	0	40
Loan (%)	80	40
Economic IRR (%) / Financial IRR	41.8 / 15	45.2 / 15
Economic IRR (%) / Financial IRR	47.9 / 20	50.2 / 20

Project 5: Upgrading of operations in landfills

The operation of landfills in Georgia is in general very limited. Poti is no exception. This project explores the feasibility and return from upgrading landfills, taking as an example the landfill in Poti. We keep expenditures to the minimum, and only include the equipment that is necessary for improved operation of the existing landfill.

Table 19: Equipment Costs for Improved Operation of Landfill (USD)

	Number	Unit Price	Cost
New bulldozer	1	50 000	50 000
New truck	1	30 000	30 000
New compactor	1	25 000	25 000
Capital repair of old equipment			5 000
Total			**110 000**

Source: Own estimates.

Table 19 shows that equipment costs amount to USD 110 000. Table 20 shows the corresponding O&M annual costs.

Table 20: Annual Operation and Maintenance Costs for Improved Operation of Existing Landfill (USD)

	Category	Unite value	Number	Total
1	Wage fund: *Administration*	60	1	720
2	*Mechanics*	40	1	480
3	*Drivers*	50	3	1 800
4	*Wage fund in total*			*3 000*
5	Taxes (31% of wage fund)			930
6	Maintenance costs (repair of trucks, spear parts, etc.)			3 000
Total				**6 930**

Source: Own estimates.

Finally, Table 21 shows the increase in fees required for different combinations of grants and loans that ensure a financial IRR or 15% or 20%.

Table 21: Increase in Fees (in USD/Capita/Month)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fees (IRR=15 %)	0.56	0.48	0.41	0.33	0.26
5	Increase in fees (IRR=20 %)	0.6	0.52	0.44	0.36	0.28
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fees (IRR=15 %)	0.62	0.53	0.44	0.35	0.26
5	Increase in fees (IRR=20 %)	0.67	0.57	0.47	0.38	0.28

Closing of existing landfills and establishment of new ones

The existing landfill is located 7 km north-east from Poti on the embankment of the river Rioni. It is not well organised, all the sanitary norms regarding waste treatment are violated, and the surrounding area gets polluted. Ever since the landfill opened, rainwater has been running into the river Rioni, which has been carrying waste into the Black Sea. The existing landfill is not equipped to cover the waste with soil; re-cultivation has not been carried out in recent years, and no geological studies were done in the beginning. The groundwater level is mostly near the surface. Moreover, the landfill is not fenced off and animals can get into the site and search for food, which also violates sanitary standards.

Based on the above description and given the existing hazards, the closure of the present landfill in Poti is an alternative option to building a separating wall (see Project 2).

There is no experience in Georgia with landfill closure that would satisfy modern requirements; as a rule, this has included only covering the landfill with soil and compacting. Because of this lack of experience, the costs of closure in compliance with all requirements are difficult to calculate and only estimations are available. In particular, the cost of closing the Poti landfill is estimated in the range of USD 150 000 to 250 000.

It is important to note, however, that even if the landfill were closed satisfying all necessary procedures, it would still be necessary to build a concrete wall along the whole river bank, as the Rioni river cuts away about 3-4 m of the landfill per year. So, before the municipality decides on a future use of the landfill site, fencing and planting a buffer zone are desirable.

Total closing costs for the Poti landfill are given in Table 22.

A new waste disposal site in Poti has been under consideration for a long time now, but the Poti Council has not been able to solve this problem because of financial constraints. While it is difficult to calculate exactly the cost of opening a new landfill, various experts estimate that opening a new landfill of 3 ha^2 in Poti would cost in the range of USD 870 000 to 1 190 000 (see Table 22).

Table 22: Costs of Closing an Existing Landfill and Opening a New Landfill (in USD)

	Costs	
	Minimum	**Maximum**
Closing existing landfill		
Closing procedures, including the construction of a final impermeable cover	150 000	250 000
Concrete wall construction costs	215 000	215 000
Fencing and planting	25 000	25 000
Total costs for closing of existing landfill	***390 000***	***490 000***
Opening a new landfill		
Design	15 000	25 000
Hydrogeological survey (investigations)	20 000	30 000
Construction-and-assembling operations	700 000	1 000 000
New equipment	110 000	110 000
Fencing and planting	25 000	25 000
Total costs of opening a new landfill	***870 000***	***1 190 000***
Total	**1 260 000**	**1 680 000**

Source: Own estimates.
Note: While making these calculations, it was assumed that the project lifetime, i.e. the operating period of the landfill, is equal to 20 years.

Table 23 shows the increase in fees required for different combinations of grants and loans that would ensure a financial IRR of 15% or 20%.

Table 23: Increase in Fees in USD/Capita/Month (Equity Capital = 20 % of Total Investment)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	20	40	60	80
2	Soft loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fees (IRR=15 %)	22.8 – 37.0	17.6 – 28.4	12.4 – 19.7	7.4 – 11.4	2.7 – 3.5
5	Increase in fees (IRR=20 %)	26.0 – 42.4	20.1 – 32.4	14.2 – 22.5	8.3 – 12.9	2.8 – 3.7
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	20	40	60	80
2	Moderate loan (%)	80	60	40	20	0
3	Equity capital (%)	20	20	20	20	20
4	Increase in fees (IRR=15 %)	26.9 – 44.0	20.7 – 33.5	14.5 – 23.2	8.4 – 13.0	2.7 – 3.5
5	Increase in fees (IRR=20 %)	30.9 – 50.5	23.7 – 38.5	16.5 – 26.6	9.5 – 14.8	2.8 – 3.7

In the above calculations, the equity was assumed to equal 20% of total investment, i.e. USD 252 000 – 336 000. It is not probable that the municipality of Poti can allocate such financial resources. Therefore, additional calculations have been carried out for a zero share of equity capital. The results are presented in Table 24.

Table 24: Increase in Fees in USD/Capita/Month (Equity Capital = 0)

Soft Loan (5 Years, Interest = 4 %)						
1	Grant (%)	0	25	50	75	100
2	Soft loan (%)	100	75	50	25	0
3	Equity capital (%)	0	0	0	0	0
4	Increase in fees (IRR=15 %)	34.6 – 45.7	26.4 – 34.9	18.3 – 24.0	10.4 – 13.4	3.0 – 3.5
5	Increase in fees (IRR=20 %)	39.6 – 52.2	30.2 – 39.9	21.0 – 27.5	11.8 – 15.3	3.1 – 3.7
Moderate Loan (5 Years, Interest = 12 %)						
1	Grant (%)	0	25	50	75	100
2	Moderate loan (%)	100	75	50	25	0
3	Equity capital (%)	0	0	0	0	0
4	Increase in fees (IRR=15 %)	41.1 – 54.3	31.3 – 41.4	21.6 – 28.4	12.0 – 15.5	3.0 – 3.5
5	Increase in fees (IRR=20 %)	47.2 – 62.4	36.0 – 47.6	24.7 – 32.5	13.6 – 17.7	3.1 – 3.7

Because of the current socio-economic conditions in Georgia, this report suggests that the grant component be above 50%. Besides, due to relatively low costs on labour and building materials, a lower limit of investment is more realistic, i.e. investment = USD 1 260 000.

4.4. Value Added of DFES Investments

At present, there is very limited support for the waste management sector in Georgia – i.e. limited contributions from the Municipal Development and Decentralisation Project, the Georgian Social Investment Fund and some grants from the US Agency for International development (USAID). The almost total absence of support from the donor community means that DFES would have very few co-financing partners. On the other hand, the value added of DFES investments would be unquestionable since it would become the main source of financing for investment in this field.

5. RISKS

Technology
Low risk. The projects do not need sophisticated technologies or operational requirements. Our own survey of municipal and private operators shows that there are no problems or impediments associated with the use of current technologies.

Payment collection
Medium risk. It is usually assumed that the population would not pay for waste collection systems. However, there are experiences in Georgia that show the contrary. The private operator in Rustavi has attained collection rates of 85-93%. Collection rates depend on whether the fee is within families’ payment capacity and, most importantly, on providing good service.

Institutional and regulatory issues
Low-medium risk. The most important risks comprise (i) regulatory changes and ii) corruption. These two issues were serious problems under the previous administration of Mr. Shevardnadze. The current

government is undertaking a frontal assault on corruption within state structures, as well as promoting a regulatory setting that is business-friendly. Even though it is too early at this stage to assess the impact of these measures, we assess the risk in this area as significantly lower than in previous years.

6. ESTIMATED SIZE OF ENTIRE PROJECT PIPELINE

The report has explored five projects. All these projects share the following characteristics:

- Minimisation of waste entering international water bodies;
- Reduction of risks to public health and improvement of living conditions; and
- Increased attractiveness of the city for tourists.

Table 25 presents a summary list of the projects with a suggested ratio between grants and loans.

Table 25: Summary of Model Projects for DFES Waste Management Pipeline

#	Project	Investment in USD			
		Equity Capital	Grant	Soft Loan	Total
1	Construction of a concrete wall at the border of the landfill and river	43 000 20 %	172 000 80 %	-	215 000 100 %
2	Fencing of the existing landfill and construction of a buffer zone	4 948 20 %	9 896 40 %	9 896 40 %	24 740 100 %
3	Upgrading of operations in landfills	22 000 20 %	66 000 60 %	22 000 20 %	110 000 100 %
4	Expansion of existing waste collection systems	8 100 20 %	16 200 40 %	16 200 40 %	40 500 100 %
5	New system of waste collection and disposal (Scenario 1)	65 640 20 %	131 280 40 %	131 280 40 %	328 200 100 %
6	Closing existing landfills and establishment of new ones	0 0	945 000 75 %	315 000 25 %	1 260 000 100 %

Projects for this pipeline have been ranked according to their immediate environmental impact. The order of priority for these projects is given in Table 23. That is, it would be a priority to stop the regular flushing of waste into international waters and to upgrade operations in landfills. This could be done in parallel with improving waste collection systems in towns.

We have used as a basis the data of model projects from Poti and extrapolated the results to other locations in the Black Sea coastal area and the Kura River basin. Table 26 shows the results.

Table 26 shows that the total amount of investments ranges from USD **2 626 200 to 3 646 500**. This is so because the construction of a new landfill in Poti would exclude the costs of fencing, planting a buffer zone and constructing a separating wall. These items are already accounted for in the cost of closing and establishing a new landfill.

Table 26: Estimated Cost of Waste Management Projects for Locations in the Black Sea Coastal Area and the Kura River Basin (in USD)

No	City	Population	Project type	Estimated Investment	Project Priority
1	Tbilisi	1 073 000	Fencing and planting of buffer zone for the existing landfills (“Gldani” and “Iagludji”)	60 000	High
			Upgrading existing landfills	650 000	High
2	Kutaisi	186 000	Improvement of waste collection and removal system at the embankment of the river Rioni	120 000	High
3	Batumi	122 000	Fencing and planting of buffer zone for the existing landfill	35 000	High
			Upgrading of the existing landfill	15 000	High
			Expansion/upgrading of the existing waste collection system	210 000	Medium
			Construction of a concrete wall along the border “landfill-river Chorokhi”	350 000	Highest
4	Rustavi	116 000	Improvement of waste collection and removal system for high-rise buildings	30 000	Medium
			Improvement of waste collection and removal system at the embankment of River Kura	42 000	Highest
5	Zugdidi	69 000	Fencing and planting of buffer zone for the existing landfill	30 000	High
			Upgrading of the existing landfill	15 000	High
			Expansion/upgrading of the existing waste collection system	60 000	Medium
6	Gori	50 000	Fencing and planting of buffer zone for the existing landfill	25 000	High
7	Poti	47 000	Fencing and planting of buffer zone for the existing landfill	24 700	High
			Construction of a concrete wall along the border “landfill-river Rioni”	215 000	Highest
			Expansion of the existing waste collection system	40 500	Medium
			New system of waste collection and disposal	516 000	Medium
			Upgrading of the existing landfill	110 000	High
			Closing of the existing landfill and opening a new landfill	1 260 000	Highest
8	Zestaponi	24 200	Fencing and planting of buffer zone for the existing landfill	11 000	High
9	Kobuleti	18 600	Improvement of waste collection and removal system in the Black Sea coastal zone	45 000	Highest
10	Mtskheta		Fencing and planting of buffer zone for the existing landfill	7 000	High
			Improvement of waste collection and removal system at the embankment of the river Kura	15 000	Highest

Source: Own estimates.

The report estimates that 2 locations would apply for DFES resources every year. This rather low application rate is based on the pessimistic assumption that the requirement for realistic collection and disposal fees for waste collection and disposal will deter some municipalities. Under these assumptions, the period for disbursement of USD 2 626 200 USD – 3 646 500 has been estimated at a maximum of 5 years. After this period, an impact assessment should be conducted and future DFES disbursement re-estimated.

7. REFERENCES

1. World Bank (1996), *Waste Management Diagnostic Study. Republic of Georgia*. World Bank, Tbilisi.

WASTEWATER MANAGEMENT

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ACRONYMS

ASPM	Agency for State Property Management (former MSPM)
CBA	Cost-Benefit Analysis
DFES	Debt-for-Environment Swap
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
GDP	Gross Domestic Product
GEL	Georgian Currency Lari
JSC	Joint-Stock Companies
LLC	Limited Liability Companies
MAD	Maximum Admissible Discharges
MENRP	Ministry of Environment and Natural Resources Protection of Georgia
MoE	Ministry of Economy of Georgia
MoF	Ministry of Finance of Georgia
MoID	Ministry of Infrastructure and Development of Georgia
MoLHSA	Ministry of Labour, Health and Social Affairs of Georgia
MSPM	(former) Ministry of State Property Management
N/A	Non-Applicable
O&M	Operation and Maintenance (costs)
Tetri	0.01 GEL
USAID	US Agency for International Development
USD	US Dollar
USEPA	US Environmental Protection Agency
VAT	Value-Added Tax

PHYSICAL UNITS

cm	Centimetre
km	Kilometre
kW/h	Kilowatt per hour
m^2	Square metre
m^3	Cubic metre
m^3/d	Cubic metre per day

SYNTHESIS

This report begins with a description of the wastewater sector of Georgia, followed by a brief overview of community wastewater management systems. It then explores the feasibility of different types of wastewater systems, and suggests the most appropriate ones given the local conditions. The report concludes with strategies for investing DFES resources.

Projects in the wastewater project pipeline are grouped according to population size. The **first category of projects** comprises single facilities/dwellings or a cluster of facilities/dwellings with a maximum wastewater flow of 100 m^3. For onsite treatment of wastewater, the report considers the following types of systems:

- Septic systems. A septic tank or a series of septic tanks followed by any of these systems: (i) absorption field; (ii) lagoon; (iii) sand filter; (iv) constructed wetland; or (v) a combination of these systems.
- Non-septic systems. The same technologies listed above (except for the absorption field), but without a septic tank. In this case, some type of preliminary treatment will be required, such as course screening, grit traps, sedimentation tanks, etc.
- Package wastewater treatment plant or other mechanical treatment technology.

The economic calculations show that the costs of treatment are affordable. For example, the cost of onsite wastewater treatment would be no more than 0.12 GEL/day for a hotel guest. This increase would be negligible, as hotels near the coastal area cost 30-50 GEL/day on average. For a hospital patient, the increase would be no more than 0.29 GEL/day.

The **second category of projects** comprises small communities, towns or parts of towns with sewerage systems and with a population not exceeding 25 000 residents. This population generates a wastewater flow of 5 000 cubic metres per day (m3/d). For the treatment of wastewater from small communities, the report considers the following types of systems:

- Lagoons; recirculating sand filters; constructed wetlands or a combination of these systems. Minimum preliminary treatment with manually cleaned bar screens and grit chambers.
- Package wastewater treatment plants or other mechanical treatment technologies.

The report shows that for flows of 1 000 m^3/d, the tariff per person ranges from GEL 0.138 to 0.816, depending on the technology used. In case of flow rates of 5 000m^3/d, the tariff ranges from GEL 0.066 to 0.804. For the purpose of comparison, water tariffs in different regions of Georgia range between GEL 0.2 and 1.2.

The **third category of projects** envisages the rehabilitation of large centralised wastewater treatment facilities. The report explores the feasibility of rehabilitating the Gardabani treatment plant, which serves the cities of Gardabani, Tbilisi, and Rustavi. The Gardabani treatment plant currently receives 612 000 m^3/d of wastewater. If primary and secondary treatment costs are included, the per unit cost would be

0.032 GEL/m^3. Thus, if an individual generates 0.2 m^3 of wastewater daily, she/he would be paying 0.20 GEL/month for treating wastewater. At present, she/he pays approximately 0.04 GEL/month.

In order to maximise the impact of the resources from the debt-for-environment swap (DFES), the report explores which wastewater treatment option provides the maximum impact per dollar invested. This report proposes that at least five variables be taken into account. The first is the size of investments; the second is the volume (m^3) of wastewater treated per dollar invested. This indicates whether it is better to invest in a single major project (e.g. Gardabani) or in several smaller ones.

The third factor is the location of the source of pollution. From a donor's point of view, cities located along the Black Sea coastal area and the urban cluster of Tbilisi-Rustavi may matter more than small settlements in between. This is so because those in the coastal belt discharge directly into the Black Sea, an international water body, and Tbilisi-Rustavi is the main point of pollution of the Kura River and affects the water supply of Azerbaijan, contributing to cross-border tensions. From a national perspective, towns along the Black Sea coast and settlements higher up the Kura River may matter more. The first because improved water quality will have an impact on tourism revenues, and treating wastewater discharge of towns located along upper sections of the Kura River has a cumulative effect downstream, decreasing costs of wastewater treatment and diminishing the negative impact of water-borne diseases.

The fourth factor explored is risk. Projects under decentralised management have higher risk factors than projects under centralised management. This is mostly due to the fact that there is almost no experience in the country using alternative treatment technologies.

The fifth factor is sustainability, which depends on charging the true cost of wastewater treatment. If the political will is there, it may be possible that big urban settlements will have a greater capacity than smaller ones to increase collection rates, for example by tying the electricity bill to water supply and water treatment charges, as in the case of Tbilisi. Smaller settlements may lack this option. Having said that, it is by no means certain that bigger settlements will indeed show a greater willingness to cover the true costs of wastewater treatment.

The report closes with the following conclusions:

- If DFES resources for the wastewater management pipeline can go as high as GEL 15.5 million over 4 or 8 years, *and benefits are accounted for from a regional perspective*, then it would be advisable to invest this amount in the rehabilitation of the Gardabani plant, because:
  - It achieves the maximum reduction in the level of pollution per unit of dollar invested;
  - It will reduce tensions between Georgia and Azerbaijan; and
  - Sustainability of investment could be ensured as Tbilisi and Rustavi have greater means to charge the true costs of wastewater treatment. Georgia could also enter into cost-sharing agreements with Azerbaijan, the primary beneficiary of investments in Gardabani. (This option exceeds the scope of analysis of this report and therefore will not be explored further here).
- If settlements along the Black Sea coastal area and those along the upper section of the Kura River are prioritised, the same amount as indicated above (GEL 15.5 million) could be alternatively invested in treatment units of 5 000 m^3/d in settlements with an established sewerage network. This option would result in a larger amount of wastewater being treated than with an equivalent investment in smaller units.
- For smaller revenue flows available from the DFES programme, onsite decentralised management options become the preferred choice.
- There can be a mix of project categories in case DFES has sufficient funds.

1. INTRODUCTION

The main goal of this project pipeline is to reduce pollution of international waters along the Black Sea coastal areas and the Kura-Aras basin. To achieve this goal, the pipeline aims to improve wastewater collection and treatment utilising both conventional (centralised) and alternative (decentralised) technologies.

Projects in the international waters pipeline are grouped according to population size, which gives an indication of the wastewater flow rate. The first category of projects comprises single facilities/dwellings or a cluster of facilities/dwellings with a maximum wastewater flow rate of 100 m^3/d. The second category of projects comprises small communities, towns or parts of towns with a population not exceeding 25 000 residents. This population generates a wastewater flow rate of 5 000 m^3/d. The last category of projects envisages the rehabilitation of centralised wastewater treatment and collection facilities.

This report begins with a description of the wastewater sector of Georgia, followed by a brief overview of community wastewater management systems. It then explores the feasibility of different types of wastewater systems and suggests the most appropriate ones given the local conditions. Finally, the report examines whether DFES should invest in large-scale (centralised) or small (decentralised) systems and provides suggestions for investments under different assumptions of the pipeline size.

2. OVERVIEW OF THE WASTEWATER SECTOR OF GEORGIA

2.1. Institutional Framework

The institutional structure in the field of water and wastewater management in Georgia is complicated and involves the following:

- The Ministry of Environment and Natural Resources Protection;
- The Ministry of Infrastructure and Development;
- Geowatercanal;
- The Agency for State Property Management (under the Ministry of Economy);
- Municipalities;
- The Ministry of Economy;[58] and,
- The Ministry of Labour, Health and Social Affairs.

The following is a description of their main roles and responsibilities:

<u>The Ministry of Environment and Natural Resources Protection</u>
The main institution in charge of the development and implementation of environmental policy is the Ministry of Environment and Natural Resources Protection of Georgia (MENRP). The Ministry has responsibilities in all areas of environment, including water resources management and protection. The

[58] Transformed into the Ministry of Economic Development.

MENRP elaborates the strategy for the sector and is responsible for regulation, legislation, supervision, control, organisation and coordination. Specifically, the Ministry is charged with:

- Natural resources (including water) use licensing;
- Wastewater discharge licensing (all municipal, industrial or other facilities that have direct discharge of wastewater into a surface water body need a license for wastewater discharge). The license is based on maximum admissible discharges (MAD) and is issued by the Ministry of Environment or its regional bodies based on a decision of the "Interdepartmental Council Body of Experts" or "Regional Experts Councils";
- Issuing of environmental permits. They are required for certain types of development projects, such as roads, mining, etc. The Ministry of Environment or its regional or local bodies issue the permit based on the results of an environmental impact assessment (EIA); and
- Controlling pollution.

Ministry of Infrastructure and Development[59]

During the period of 1998-2003, the former Ministry of Urbanisation and Construction was responsible for the supervision, coordination, control and implementation of a common water supply and sewerage systems policy at the municipal level. The ministry developed policies for the sector and planned the construction of water supply and sewerage facilities. It also coordinated its actions with the former Ministry of State Property Management (MSPM) and the Ministry of Economy.[60] In 2004, the Ministry of Urbanisation and Construction was abolished and its functions in the field of municipal water supply and wastewater service were transferred to the new Ministry of Infrastructure and Development.

Geowatercanal

Geowatercanal Ltd, which operates under the Agency for State Property Management at the Ministry of Economy, supervises, coordinates and exercises control over water utility companies. In addition to these management functions, it operates the Gardabani regional wastewater treatment plant, which treats wastewater from Tbilisi, Rustavi and Gardabani. Geowatercanal also sets regulations for water supply and sewerage systems, such as:

- The Rules on the Use of Municipal Water Supply and Sewerage Systems adopted in 1998. These rules set water consumption norms for different users, and procedures and conditions for connection to the municipal network.
- The Rules on the Technical Exploitation of Municipal Water Supply Systems and Networks adopted in 2000. These rules define conditions of operation of different water supply facilities and networks.
- The Rules on Receiving Industrial Wastewater into the Sewerage Network (1999).

Agency for State Property Management

Water supply and sewerage systems are run by enterprises that are either joint-stock companies (JSCs) or limited liability companies (LLCs). These enterprises are supposed to operate on the principles of self-financing, but in reality they often receive budgetary support from municipalities and from the central government (average annual subsidy is about GEL 6 million). The municipality controls the budget allocation and tariffs. All utilities have a 100 % state ownership through the Agency for State Property Management at the Ministry of Economy.

Municipalities

[59] The Ministry has been restructured and merged with the Ministry of Economic Development.

[60] Starting from 2003, the Agency for State Property Management is under the Ministry of Economic Development.

Municipalities are responsible to consumers for ensuring an uninterrupted water supply of drinking quality. They also facilitate resources for investments in the water supply and sewerage systems, for otherwise the utility companies would be unable to ensure the minimum levels of maintenance. In fact, municipalities are obliged to subsidise shortfalls in the income of utility companies.

Ministry of Economy
The Ministry of Economy identifies capital investment projects, prepares indicative plans for their implementation and coordinates related tariff structures. The Ministry of Finance allocates funds for the development of capital investment projects. The Tax Inspection, subordinated to the Ministry, is responsible for collecting taxes for water extraction and wastewater discharge.

Ministry of Labour, Health and Social Affairs
The Ministry of Labour, Health and Social Affairs (MoLHSA) develops and approves sanitary rules and norms to guarantee a safe environment for the population. For example, the Ministry develops and approves norms for surface water resources that are used for drinking, and for domestic and recreational purposes.

2.2. Tariff Policy

The tariffs for water supply and wastewater services are set and approved by municipalities with the consent of the Ministry of Finance. Basically, there are two tariff rates: a low rate for the population and a higher rate for industrial companies and institutions. The tariffs in force are very low. For households, they range from 20 to 120 Tetris, depending on the region. For industry, the tariff is between GEL 1.6-4.6 in Tbilisi. The current collection rate is estimated at 20-25 % for households, and 60% for other consumers (industry and institutions). As a result, the finances of water utilities are in very bad shape.

This was supposed to change with the ”1999-2005 Programme for the Establishment of Water Supply and Wastewater Disposal Systems, Operation Costs and Payment by the Population for Water Consumption”. Approved in 1998 by presidential decree, the programme established the beneficiary-to-pay principle for water supply and sewer services. It also provided for a gradual increase in tariffs. In fact, starting in 2005, municipal budgets were supposed to stop subsidising water companies. However, no plan for the revision of the tariff structure has been announced yet.

2.3. Water Legislation

There are about 30 major laws in Georgia that have significant influence over water resources management and protection. The most important ones are:

- *The Law on Environmental Protection.* The Parliament of Georgia adopted this law in 1996. It is a framework legislative act, which defines the general principles of natural resources (including water) management, licensing, supervision and control, and sets environmental standards and the use of economic instruments.
- *The Law on Environmental Permits.* The Parliament of Georgia adopted this law in 1996. It establishes the legal basis for issuing environmental permits. All new municipal, industrial, agricultural and other enterprises are required to have these permits. According to the potential impacts that they may have on the environment, all business activities are divided into four categories. For business activities that come under the first category (which includes sewerage systems and municipal treatment plants), permits are granted only after a full environmental impact assessment (EIA) has been carried out and the report has been evaluated by the Ministry of Environment. While investors are responsible for paying and organising the EIA process for their project, they are authorised to select an environmental consulting firm for undertaking the EIA.

- *The Law on Water of Georgia.* The Parliament of Georgia adopted this law in 1997. It establishes that water is state property and creates the legal basis for extraction and discharge of water. Among all potential uses, the law sets the highest priority for drinking use, and defines the principles for setting water protection zones, surface water quality standards (norms), wastewater discharge limits and enforcement mechanisms.
- *The Law on Health Protection.* The Parliament of Georgia adopted this law in 1997. It defines risk factors on health, including risks from non-drinkable water.
- *The Tax Code of Georgia.* The Parliament of Georgia adopted this code in 1997[61]. It sets water use and emission tariffs. Any discharge of water pollutants from a point source is subject to a pollution charge.
- *The Sanitary Code of Georgia.* The Parliament of Georgia adopted this code in 2003. It defines the sanitary-hygiene norms and describes the responsibilities of different authorities for ensuring compliance.

2.4. Conditions of Sewerage Systems and Wastewater Treatment Plants

The Soviet period managed to put in place an extensive network of sewerage systems and wastewater treatment plants. Centralised sewerage systems exist in 45 towns and settlements of Georgia, with a total length of approximately 4 000 km. Almost half (47.6%) of the population is connected to the centralised sewage systems.

However, the conditions of the sewerage systems are very poor. The lack of maintenance has led to severe deterioration. About 1 520 km of the sewerage network need renovation. Annually, about GEL 4 million would be required for repairs. At present, only GEL 1.2 million are allocated.

Table 1. Main Technical Parameters of Municipal Sewerage Systems (Excluding Abkhazia)

Type of Town	Population	Number of Towns with Centralised Sewerage Systems	Length of Collectors and Networks, km
I	< 1 500	1	2.0
II	1 500 - 10 000	13	188.6
III	10 000 - 25 000	8	235.8
IV	25 000 - 50000	8	376.2
V	50 000 – 100 000 (Gori, Zugdidi, Poti)	3	134.6
VI	>100 000 (Tbilisi, Kutaisi, Rustavi, Batumi)	4	2941.2
Total:		**37**	**3 878.4**

Source: Ministry of Environment and Natural Resources Protection of Georgia.

Over a decade ago, wastewater treatment facilities were operating in 29 towns (4 of them regional), with a total capacity of 1 596 200 m^3/day. Traditional biological treatment plants existed in 26 towns, with a total designed capacity of 1 428 400 m^3/day. Treatment plants with mechanical treatment were present in only 7 residential areas with a total capacity of 167 800 m^3/day.

All municipal wastewater treatment plants started operations before 1990. However, after more than a decade without minimal maintenance work, all of them are either non-operational or in a very poor state. The few of them that still work (Tbilisi-Rustavi, Kutaisi, Batumi, Khashuri, Gori) provide only mechanical treatment. No plant provides secondary or biological treatment.

[61] The new simplified Tax Code was approved in December 2004 and entered into force on 1 January 2005.

As a result, municipal sewage can be considered as the largest source of surface water pollution in Georgia (about 80% of the overall wastewater volume is discharged into surface water bodies). Contaminated surface and ground water is believed to be a major cause of infectious and parasitic diseases that adversely affect the health of the population. According to data from the Disease Control Centre of the MoLHSA, each year there are outbreaks of diarrhea, amebiasis, typhoid fever and other diseases related to the poor quality of the water supply.

3. POTENTIAL PROJECTS FOR DFES FINANCING

The characteristics of the three categories of wastewater treatment projects are described below.

3.1. Project Category 1: Onsite Wastewater Management

Background and rationale

About half of the Georgian population is not served by centralised sewerage systems. This is so mostly in rural areas of low population density. Here, the local population uses traditional pit latrines or improved pit latrines – a concrete container placed in the soil from which the septage is pumped out periodically. In a pit latrine, the solids settle but the liquid seeps directly into the soil. This can have serious effects on the quality of the nearby (ground) water.

In contrast, improved pit latrines do not threaten groundwater, though they are a source of pollution of surface waters as the pumped septage in most cases is discharged untreated into the nearest water stream. This is a major source of pollution for coastal areas and settlements in the Kura basin. Of particular concern is the effluents from hospitals, which are not treated and thus contribute to the propagation of diseases through the pollution of both ground and surface waters with infectious substances.

In view of the above, there would be international and national benefits from installing low-tech, low cost onsite treatment technologies for commercial, industrial, municipal and residential developments in unsewered areas, either for individual facilities/dwellings or a cluster of facilities/dwellings.

Objectives

- Reduce pollution of the natural environment;
- Improve environmental, sanitary and health conditions;
- Allow municipal and/or industrial effluents to be disposed of without danger to human health;
- Introduce and demonstrate appropriate technologies for onsite wastewater treatment; and
- Provide opportunities for generating economic benefits from reuse and recycling.

Beneficiaries

Public institutions, e.g. schools, hospitals, prisons, military camps, etc. and/or private businesses - restaurants, hotels, resorts, industrial enterprises, and cluster of residences.

Selection criteria

A crucial criterion is the ability to cover operation and maintenance costs. Priority will be given to facilities that pose the highest risk to human health and pollution of international waters.

Proposed technologies and design characteristics

For onsite treatment of wastewaters, the following types of systems can be considered:

1. Septic systems. A septic tank or a series of septic tanks followed by any of the following systems: (i) absorption field; (ii) lagoon; (iii) sand filter; (iv) constructed wetland; or (v) a combination of these systems.
2. Non-septic systems. The same technologies listed above (except for the absorption field), but without a septic tank. In this case some type of preliminary treatment will be required, such as course screening, grit traps, sedimentation tanks, etc.
3. Package wastewater treatment plants or other mechanical treatment technology.

Each of the above technologies has its advantages and disadvantages. The selection of the technology will depend on:

- Site conditions;
- Existing and future wastewater flows - hydraulic loading rate;
- Land availability;
- Reliability of electricity supply;
- Ability to maintain the system;
- Effluent discharge limits in a particular area;
- Public acceptance of the technology; and
- Climatic conditions.

For example, constructed wetlands would be appropriate in western Georgia near the coastline due to favourable climatic conditions, and package wastewater treatment plants would be appropriate in areas where land availability is an issue. Table 2 below provides information about the land area requirements of various technologies broken down by the volume of effluent to be treated (the land area for natural systems includes the area occupied by septic tanks).

Table 2. Land Area Requirement of Various Technologies (m^2)

Technologies	Wastewater Flow Rate (m^3/d)	
	10	100
Lagoon	200	2 000
Intermittent sand filter	343	Not recommended
Recirculating sand filter	170	1 700
Sub-surface flow wetland	147	1 621
Mechanical/package treatment plant	34	180

Source: Own estimates.

The size of the system depends on the wastewater flow rate, which in turn depends on the facility being considered. For example, it is estimated that on average a wastewater flow rate of 10 m^3/d can result from a hotel with 50 guests, a school with 200 children or a hospital with 20 beds.

Investment cost estimates

Investment costs of onsite wastewater treatment systems include the design and construction costs. The calculations assume that sludge pumping and disposal are outsourced and therefore no provisions for purchasing pumping vehicles or constructing sludge disposal sites have been taken into account.

For natural treatment systems, the investment costs include the design and construction costs of lagoons, sand filters or constructed wetlands, plus the design and construction costs of septic tanks. Construction costs were obtained based on the design characteristics of various systems and by estimating the cost of separate components.[62] The costs of various kinds of work, such as soil excavation, backfilling, compacting, clay lining, etc., were obtained from projects financed by the Georgian Social Investment Fund and implemented in Georgia in the recent past. Costs of construction materials are based on market prices of inputs as of May 2004.

Table 3 provides a summary of investment costs of treatment facilities for two different wastewater flow rates – 10 m^3 and 100 m^3. There are two cost estimates for natural treatment technologies – systems with bottom-lining and systems without it. In areas where soils are slowly permeable, there is no need for lining the bottom part of the systems.

Table 3. Investment Costs of Onsite Treatment Technologies (in GEL)

Technologies	Natural Systems with Lining		Natural Systems without Lining	
	10 m^3	100 m^3	10 m^3	100 m^3
Lagoon	24 815	131 258	22 573	110 210
Intermittent sand filter	44 472	Not recommended	40 440	Not recommended
Recirculating sand filter	35 761	195 553	34 131	180 520
Sub-surface flow wetland	29 375	183 147	27 523	166 883
Mechanical/package treatment plant	35 000	190 000	35 000	190 000

Source: Own estimates.

Table 3 shows that lagoons have the lowest capital costs – ranging from GEL 22 500 to 25 000. It should be noted, however, that these costs would vary depending on the characteristics of the wastewater and site conditions (accessibility, distances from manufacturers, soil conditions, availability of trucks in the area, etc.).

Operation and maintenance cost estimates

Operation and maintenance costs were estimated based on the manpower, energy and sludge removal/handling requirements of various systems. Tables 4 and 5 provide the summary of operation and maintenance (O&M) costs for various technologies.

[62] The investment and O&M cost breakdown for all systems explored in this report may be obtained by contacting Ms. Nino Partskhaladze at ninopar@hotmail.com

Table 4. Operation and Maintenance Annual Cost Estimates for Onsite Treatment Technologies (GEL)

Technologies	Wastewater Flow Rate	
	10 m^3	**100 m^3**
Lagoon	415	2 220
Intermittent sand filter	291	Not recommended
Recirculating sand filter	561	1 929
Sub-surface flow wetland	353	1 602
Mechanical/package treatment plant	2 046	5 278

Source: Own estimates.

Table 5. Costs of Treating 1 m^3 of Wastewater with Onsite Treatment Technologies (GEL)

Technologies	Wastewater Flow Rate	
	10 m^3	**100 m^3**
Lagoon	0.114	0.061
Intermittent sand filter	0.080	Not recommended
Recirculating sand filter	0.154	0.053
Sub-surface flow wetland	0.097	0.044
Mechanical/package treatment plant	0.562	0.145

Source: Own estimates.

The above cost estimates are based on the following assumptions:

- Natural treatment systems require non-skilled operation and maintenance personnel to visit the facility once a week – check the system, make repairs, cut the grass when needed.
- Sludge removal from the septic tank is required once every 3 years.
- Sludge removal from lagoons is required once every 10 years.
- Sludge removal includes disinfection, pumping and transportation to the sludge disposal field.
- Gravel media and vegetation replacement for sub-surface flow wetlands can be required once every 10 years.
- The costs of pumping and of re-establishing vegetation (for wetlands) are annualised. The cost of pumping can vary greatly, depending on the distance from treatment facilities to the sludge disposal site.
- Mechanical treatment plants utilise activated sludge treatment processes and their costs are mainly for manpower and energy requirements.
- O&M costs do not include debt service expenses.

Economic and financial aspects

Costs

The examples below show how much the facility (e.g. hospital or hotel) should charge the customer to cover operation and maintenance expenses of wastewater treatment technologies. In making these calculations, it has been assumed that the facilities do not use loan financing of capital investment and that they operate at their full capacity.

Table 6. Wastewater Treatment Costs per Person per Day – an Example of a Hotel (in GEL)

Technologies	Wastewater Flow Rate	
	10 m^3 Hotel with 50 Guests	100 m^3 Hotel with 500 Guests
Lagoon	0.023	0.012
Intermittent sand filter	0.016	Not recommended
Recirculating sand filter	0.031	0.011
Sub-surface flow wetland	0.019	0.009
Mechanical/package treatment plant	0.112	0.029

Source: Own estimates.

Table 7. Wastewater Treatment Costs per Person per Day – an Example of a Hospital (GEL)

Technologies	Wastewater Flow Rate	
	10 m^3 Hospital with 20 Beds	100 m^3 Hospital with 200 Beds
Lagoon	0.057	0.03
Intermittent sand filter	0.040	Not Recommended
Recirculating sand filter	0.077	0.026
Sub-surface flow wetland	0.049	0.022
Mechanical/package treatment plant	0.281	0.072

Source: Own estimates.

The above examples show that even with the use of the most expensive technology (package plant), the cost of treatment would be no more than 0.12 GEL per day for a hotel guest. This increase would be negligible, as hotels near coastal areas cost 30-50 GEL per day on average. For a hospital patient, the increase would be no more than GEL 0.29. Therefore, for such institutions, the cost of wastewater treatment is affordable. The same applies to restaurants, private schools and other establishments that charge customers for services. The cost of wastewater treatment should also be affordable for industrial enterprises producing goods (e.g. pig and cattle farms, fertiliser factories, etc.), as it is unlikely to cause a significant rise in the price of their goods.

Demand for services

In order to have an idea of the potential demand for these types of projects, the tables below provide information on the number and category of various facilities that may be eligible for DFES financing.

Table 8. Number of Hotels and their Size by Type and Location (2003)

Region	Number of Hotels	Number of Places	Number of Places per Hotel
Tbilisi	92	7 952	86
Mtskheta-Mtianeti	18	1 050	58
Adjara	30	2 731	91
Samegrelo, Zemo Svaneti	17	1 356	80
Racha-Lechkhumi, Kvemo Svaneti	3	263	88
Guria	3	293	98
Kakheti	8	628	79
Shida Kartli	8	665	83
Imereti	23	2 606	113
Samtskhe-Javakheti	25	1 812	72
Kvemo Kartli	2	62	31
Tskhinvali	n/a	n/a	n/a
Abkhazia	n/a	n/a	n/a
Georgia	**229**	**19 418**	

Source: State Department for Statistics.
Note: n/a – Non applicable.

Table 9. Number of Hospitals and their Size by Type and Location (2002)

Region	Number of Hospitals	Number of Beds	Number of Beds per Hospital
Tbilisi	66	7 120	108
Mtskheta-Mtianeti	6	188	31
Adjara	21	1 676	80
Samegrelo, Zemo Svaneti	27	1 275	47
Racha-Lechkhumi, Kvemo Svaneti	5	265	53
Guria	8	455	57
Kakheti	19	770	41
Shida Kartli	14	966	69
Imereti	34	2 272	67
Samtskhe-Javakheti	13	727	56
Kvemo Kartli	24	1 109	46
Tskhinvali	1	15	15
Abkhazia	1	20	20
Hospitals subordinated to various institutions	12	1 432	119
Georgia	**251**	**18 290**	

Source: State Department for Statistics.

The above establishments in Tbilisi are connected to the centralised wastewater collection system. Some of the facilities in Batumi (Adjara), Kutaisi (Imereti), Khashuri and Gori (Shida Kartli) can also be connected to the sewerage systems. These are towns where primary wastewater treatment works to a certain degree. As to facilities located in other parts of Georgia, their wastewater is not treated at all, even if they are connected to the sewerage system. The number of hotels and hospitals without wastewater treatment in Georgia is estimated to be about **200**.

Tables 10 and 11 present information on educational institutions in Georgia. Their number significantly exceeds the number of hotels and hospitals, and it is estimated that a couple of thousand educational institutions may need onsite wastewater treatment systems.

Table 10. Number of Preschool Institutions and Places (2002)

Region	Number of Preschools	Number of Places	Number of Children	Occupancy Rate (%)
Tbilisi	87	33 391	24 556	74
Adjara	46	4 703	3 663	78
Guria	43	3 405	1 314	39
Imereti	221	21 339	11 781	55
Kakheti	210	17 752	9 260	52
Mtskheta-Mtianeti	60	3 889	1 945	50
Racha-Lechkhumi, Kv. Svaneti	33	1 625	1 013	62
Samegrelo, Zemo Svaneti	142	10 072	5 523	55
Samtskhe-Javakheti	33	2 795	1 607	57
Kvemo Kartli	109	13 709	7 224	53
Shida Kartli	101	8 331	4 591	55
Georgia	**1 185**	**121 011**	**72 477**	**60**

Source: Ministry of Education.

Table 11. Number of Schools and their Size by Type and Location (2002/2003 School Year)

Region	Number of State Schools	Number of Pupils in State Schools	Number of Private Schools	Number of Pupils in Private Schools	Number of Pupils per School
Tbilisi	200	155 197	66	8 624	616
Adjara	403	66 403	8	976	164
Guria	154	21 074	0	0	137
Imereti	518	101 697	24	2 061	191
Kakheti	253	59 522	9	595	229
Mtskheta-Mtianeti	196	19 301	0	0	98
Racha-Lechkhumi, Kv. Svaneti	115	6 074	0	0	53
Samegrelo, Zemo Svaneti	408	63 019	9	766	153
Samtskhe-Javakheti	253	36 295	0	0	143
Kvemo Kartli	347	80 330	6	1 295	231
Shida Kartli	253	51 163	9	1 075	199
Georgia	**3 100**	**660 075**	**131**	**15 392**	**209**

Source: Ministry of Education.

Benefits

Projects of this scale are expected to produce direct and indirect social benefits that are difficult to quantify in monetary terms. In case the treated effluent is used for irrigation purposes, then direct benefits will include the savings on irrigation water. Other direct benefits might include:

- Increment (rise) in property value;
- Increase in tourism, especially in coastal areas;
- Change in fisheries production and revenues;

- Due to improved water quality, reduction in treatment costs for water-borne diseases and fewer workdays lost; and
- Decreased pollution of international water bodies.

It should be noted that due to the small scale of these projects, the reduction in the level of pollution from a single facility will be insignificant unless nearby facilities install onsite treatment systems as well. Only then is a significant impact on fisheries production and tourism likely (if just one hotel treats its wastewater near the coastline, it will not bring more tourists). This is one of the reasons why economic analysis has not been conducted for only one facility. Finally, the financial return has not been estimated because the report assumes that given the current conditions, the charges will likely be set at a level to just cover investment and operational costs.

Institutional issues

The ownership, organisational structure, and management responsibilities for treating wastewaters will vary depending on the type of institution and the technology being considered. In case of small wastewater flows, the institution can be the owner of the treatment system. For a cluster of facilities, the ownership of the treatment system can be exercised jointly, or one institution can serve others and charge for the services.

As to the operation of the wastewater treatment systems, owners can take responsibility for operating the systems themselves, or a maintenance contract may be required. Also, a local, designated management entity might assume responsibility for the ongoing care of onsite systems within its jurisdiction.

Risk analysis

A two-step process was used in performing the risk analysis. First, an evaluation was made of the areas of potential risk for a project pipeline. Then, each risk factor was reviewed and classified as high, medium or low, according to its likelihood of occurrence and its expected scale of impact. This classification is based on expert judgment, knowledge of the current situation and previous experiences. Below is the list of risk factors, along with at least one specific mitigation measure.

Risk Factor 1: Level of infrastructure development for onsite management systems – HIGH RISK.

At present, the infrastructure for onsite wastewater management systems is underdeveloped. For example:
- There is very little or no experience in the country in designing, constructing and managing onsite wastewater treatment systems, with the exception of mechanical treatment plants.
- Georgian scientists and engineers are not experienced in designing onsite systems and therefore favour centralised wastewater management systems.
- Wastewater utility agencies that now exist in Georgia do not have the necessary skills and equipment to maintain and supervise the systems.
- Most of the remaining hauling vehicles from Soviet times, which were used for pumping sewage from individual residences, are obsolete. New hauling vehicles will be necessary for pumping septage and sludge from septic tanks and lagoons.
- At present, there are no legal provisions for regulating the proper installation, functioning and inspection of such systems.

Consideration of the above issues is very important in order to avoid improper maintenance of the systems, which may in turn affect further dissemination of alternative technologies in years to come.

Mitigation measures:

- Formulate capacity building activities to ensure appropriate technical and financial management of the systems;
- Prompt necessary policy, institutional and legal reforms so that policies for achieving better control over decentralised systems can be developed and implemented;
- Provide technical assistance to newly established utility companies or existing utility agencies in order to develop appropriate project and operational management skills for staff in wastewater enterprises; and
- Train and educate local officials so that they can provide their support in the implementation of the projects.

Risk Factor 2: Existence of demand for the projects – HIGH RISK.

The demand for onsite wastewater treatment largely depends on the enforcement of laws on pollution. It was mentioned earlier that the Law on Water of Georgia regulates the wastewater discharge limits and enforcement mechanisms. The Tax Code of Georgia also has a provision that any discharge of water pollutants from a point source is subject to a pollution charge. However, these laws are not enforced in all areas of Georgia, either because water quality monitoring in not performed or for some other reason. Under these conditions, facilities are less likely to have incentives to treat their wastewater, which would entail an increase in the price of their goods and services.

Mitigation measures:
- To reduce this risk factor, the government should enforce the laws and collect pollution charges from all non-complying facilities;
- The government may consider issuing regulations to encourage facilities to treat their wastewater and yet stay competitive (even with increased prices for their goods and services); and
- Local authorities should only allow the construction of new facilities if they can ensure that the wastewater produced by these facilities will be treated.

Risk Factor 3: Acceptability of the technology. From LOW to HIGH RISK, depending on the technology.

Because some of the natural treatment technologies may cause odour and other nuisances, such as mosquitoes, people may be against constructing them. The risk may be high with surface flow wetlands and anaerobic lagoons; as to the other natural treatment technologies, the risk is likely to be minimal.

Mitigation measure:
- The risk can be reduced by installing the technologies causing minimal nuisances.

Risk Factor 4: User support (contribution) and participation – LOW RISK.

Projects in this category may require co-financing, either in the form of cash, labour, and/or locally available materials. Such types of projects usually have a community mobilisation component (e.g. projects on schools rehabilitation). Low user participation may impact on the timely completion of the projects.

Mitigation measures:
- Conduct information and awareness building/educational programmes to ensure the involvement of beneficiaries (especially users of public facilities), develop the cooperation potential of people, and general acceptance; and

- Set certain criteria which would have to be met by sub-projects, e.g. beneficiaries would have to fulfil certain criteria, such as community involvement, to be included in the programme.

Risk Factor 5: Affordability and willingness to pay O&M expenses – from LOW to HIGH risk, depending on the facility.

The economic analysis showed that for private institutions which charge customers for goods and services, operation and maintenance cost of onsite wastewater treatment systems would be affordable. As to public institutions, such as schools, the risk can be high. Because of the low demand for wastewater treatment, parents' willingness to pay for the schools' onsite wastewater treatment is likely to be low. This may have an impact on the proper functioning of the systems. The risk depends also on the type of onsite system that is installed. Natural treatment systems require the least O&M expenses and therefore the risk will be lower.

Mitigation measures:
- Risks for public facilities can be reduced if local authorities provide subsidies for onsite wastewater treatment; and
- For natural treatment systems, community residents may be asked to provide a contribution in the form of labour, where applicable.

Risk Factor 6: Reliability of power supply – from LOW to HIGH risk, depending on the facility.

This risk factor concerns only package treatment plants and recirculating sand filters that require electricity for proper functioning. The risk is low for most of the natural treatment systems, as well as for the facilities located near mini hydropower plants.

Mitigation measure:
Risk can be minimised by adding generators to the treatment systems. However, this could significantly increase treatment costs. A second option is to have "direct purchase agreements" with power generation plants, located nearby.

Risk Factor 7: Ability to maintain the system – LOW RISK.

Maintenance requirements for natural treatment systems are low, especially for small-scale systems, and they do not require professional staff to operate them. However, if the systems are improperly managed, failures may occur.

Mitigation measures:
- System maintenance can be contracted out to an operating agency (if one has been established);
- Training can be provided for the operating personnel;
- A set of rules and regulations can be developed by which the agency will operate; and
- Once the systems have been installed, a routine monitoring schedule must be set up to ensure the long-term performance and reliability of these systems.

3.2. Project Category 2: Wastewater Management for Small Communities

Background and rationale

Table 1 showed that 22 towns in Georgia with fewer than 25 000 residents have centralised sewerage systems. The cumulative length of collectors totals 426 km, of which approximately 40% need rehabilitation. Treatment facilities exist in a few locations, but none of them work at present.

There are two types of wastewater management problems in these communities. The first is associated with leaking sewage collectors. These collectors are usually placed close to water supply pipes, which are also damaged, resulting in the contamination of drinking water and creating a public health threat. Furthermore, leaking pipes can cause cracks in buildings, if the wastewater that seeps out passes and/or accumulates beneath the foundation. This is a serious problem for the impoverished inhabitants, who have no means to fix or rebuild their homes.

The second problem is associated with the surface or sub-surface discharge of untreated wastewater. In this case the sewerage system acts as a point source of pollution. In fact, except for a few locations, sewage systems of communities located in coastal zones and in the Kura basin can be considered as a point source of pollution.

Objectives:

- Reduce pollution of the natural environment;
- Improve environmental, sanitary and health conditions;
- Introduce and demonstrate appropriate technologies for small-scale wastewater management in communities with sewerage systems; and
- Provide opportunities for generating economic benefits from reuse and recycling.

Beneficiaries

These comprise municipalities, rural settlements, towns or sections of towns.

Selection criteria

The selection criteria include:

- Communities with sewerage systems;
- Sites with the least pumping requirements (gravity collection system) and low energy demand;
- Sites with the highest threat to public health;
- Capacity of the beneficiary to operate the facility; and
- Communities planning, or already rehabilitating, water infrastructure (the Municipal Development Fund finances activities in this sector). In this case, the wastewater bill can be combined with the water bill and the increased user charge fee linked to water supply and quality improvement.

Proposed technologies and design characteristics

- Lagoons; recirculating sand filters; constructed wetlands or a combination of these systems. Minimum preliminary treatment with manually cleaned bar screens and grit chambers.
- Package wastewater treatment plants or other mechanical treatment technologies.

The land area required for wastewater treatment technologies has been calculated for two wastewater flow rates. The wastewater flow rate of 1 000 m^3/day corresponds to a population of 5 000 people, while the wastewater flow rate of 5 000 m^3/day corresponds to a population of 25 000.[63]

[63] This assumes that each person generates 200 litres of wastewater a day. This may look like a low value, but water supply is rationed in many parts of Georgia.

Table 12. Land Area Requirement of Decentralised Wastewater Treatment Technologies (m^2)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	**5 000**
Lagoon	17 000	87 000
Recirculating sand filter	13 000	65 000
Sub-surface flow wetland	13 210	66 050
Mechanical treatment plant	10 000	15 000

Source: Own estimates.

A modular design should be preferred for all natural treatment technologies. The size of the area for recirculating sand filters takes into account the area required for the recirculation tank as well. The land area requirement for mechanical treatment plants treating 5 000m^3 of wastewater daily is based on the example of a recently designed treatment plant in the Black Sea coastal town of Ureki.

It can be seen from the table above that lagoon systems have the highest land area requirements, reaching almost nine hectares for a system treating 5 000 m^3/d. In contrast, mechanical treatment plants have the least land area requirements, taking up six times less space than the lagoon systems and more than four times less space than natural filter systems.

Investment cost estimates

As with onsite treatment technologies, investment costs of wastewater treatment systems include design and construction costs. These costs, based on the design requirements of various systems, were obtained by estimating the cost of separate components.[64] The costs of various types of work, such as soil excavation, backfilling, compacting, clay lining, etc., were obtained from projects financed by the Social Investment Fund in Georgia. The costs of construction materials are based on market prices of May 2004.

Tables 13 and 14 provide a summary of investment costs for wastewater flow rates of 1 000 m^3/d and 5 000 m^3/d. There are two cost estimations for natural treatment technologies – systems with a bottom-lining requirement and systems without a lining. As mentioned above, in areas where soils are slowly permeable, there is no need to line the bottom part of the systems.

Table 13. Investment Costs of Decentralised Treatment Systems with Lining (GEL)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	**5 000**
Lagoon	338 244	1 640 604
Recirculating sand filter	1 018 824	4 840 775
Sub-surface flow wetland	878 167	4 285 568
Mechanical treatment plant	825 000	1 500 000

Source: Own estimates.

[64] The investment and O&M cost breakdown for all systems discussed in this report may be obtained by contacting Ms. Nino Partskhaladze at ninopar@hotmail.com

Table 14. Investment Costs of Decentralised Treatment Systems without Lining (GEL)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	**5 000**
Lagoon	133 466	616 714
Recirculating sand filter	869 873	4 109 806
Sub-surface flow wetland	705 398	3 421 439
Mechanical treatment plant	825 000	1 500 000

Source: Own estimates.

Depending on bottom-lining needs, investment costs for lagoons serving 25 000 people range from GEL 617 000 to GEL 1 640 000. The lining requirement for lagoons makes the system three times more expensive, whereas for other natural treatment technologies this increase is not significant. This is because the bulk of costs of filter technologies is taken up by the filter medium. Furthermore, the investment costs of mechanical treatment plants for smaller wastewater flow rates are comparable with the costs of natural treatment systems. However, for higher wastewater flows, the investment cost of mechanical treatment plants is much lower than the cost of natural treatment systems, except for lagoon treatment technology.

Operation and maintenance cost estimates

As with onsite treatment technologies, operation and maintenance costs were estimated based on the manpower, energy and sludge removal/handling requirements. Tables 15 and 16 provide the summary of O&M costs for various technologies.

Table 15. Operation and Maintenance Annual Cost Estimates (GEL)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	**5 000**
Lagoon	10 192	41 860
Recirculating sand filter	15 652	69 160
Sub-surface flow wetland	8 372	20 020
Mechanical treatment plant	49 504	243 880

Source: Own estimates.

Table 16. Costs of Treating 1m^3 of Wastewater (GEL)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	**5 000**
Lagoon	0.028	0.023
Recirculating sand filter	0.043	0.038
Sub-surface flow wetland	0.023	0.011
Mechanical treatment plant	0.136	0.134

Source: Own estimates.

The above cost estimates are based on the following assumptions:

- Natural treatment systems require non-skilled operation and maintenance personnel to visit the facility once a week (e.g. check the system, make repairs, and cut the grass when needed);
- Sludge removal from lagoons is required once every 10 years;
- Sludge removal includes disinfection, pumping and transportation to the sludge disposal field;

- Cost of chlorine for sludge disinfection can be as much as 4 GEL per m^3 depending on the solid content;
- Gravel media and vegetation replacement for sub-surface flow wetlands can be required once every 10 years;
- The costs of pumping and re-establishing vegetation (for wetlands) are annualised. The cost of pumping can vary greatly, depending on the distance from treatment facilities to the sludge disposal site;
- Mechanical treatment plants utilise activated sludge treatment processes and their costs are based mainly on manpower and energy requirements; and
- O&M costs do not include debt service expenses.

Economic and financial aspects

The examples below show the amount that the municipality (or the treatment facility) should charge the serviced population to cover operation and maintenance expenses. In making calculations, it was assumed that the facilities do not use loan financing of capital investment.

Table 17. Wastewater Treatment Costs per Person per Month (GEL)

Technologies	Wastewater Flow Rate (m^3/d)	
	1 000	5 000
Lagoon	0.168	0.138
Recirculating sand filter	0.258	0.228
Sub-surface flow wetland	0.138	0.066
Mechanical treatment plant	0.816	0.804

Source: Own estimates.

As the table shows, with mechanical treatment plants the monthly fee per person (which includes only wastewater treatment and not collection) can reach 81 Tetris. For the purpose of comparison, water tariffs in different regions of Georgia range from 20 to 120 Tetris. If we take the lowest cost technology – a wetland system serving 25 000 people – and assume that wastewater treatment fees will be linked with water fees, the combined water/wastewater bill (for 5 000 m^3/d wastewater flow rates) would increase from 5% to 30%, depending on the service area. For lagoon systems, this increase would be in the range of 12% to 70%. In case of mechanical treatment plants, the increase would be from 70% to 400%. Consequently, if land availability is not an issue, natural treatment systems are the most financially viable option.

<u>Economic aspects</u>
The economic analysis has been done for a wastewater flow of 5 000 m^3/d. Potential direct and indirect benefits include:

- Availability of water for irrigation purposes, if the effluent will be reused;
- Increase in property values;
- Increased tourism revenues, especially in coastal areas;
- Change in fisheries production and revenues;
- Generation of jobs (some people will be employed directly by the treatment facility; others may have jobs as a result of increased tourism and fisheries activities);
- Due to improved water quality, reduction in costs for treating water-borne diseases and fewer workdays lost; and
- Decreased pollution of international water bodies.

Because of difficulties in estimating the shadow prices, only two benefits from the above list (increased tourism and water for irrigation) could be calculated in monetary terms. For tourism, it was assumed that as a result of improved sanitation, approximately 750 additional tourists a year would be attracted to the resort area. Provided that each tourist spends 10 days and 50 GEL/day (accommodation, meals, transportation and other services) at the resort, the additional benefit would be in the range of 375 000 GEL a year. As for irrigation, the benefit of using treated wastewater for this purpose during six months, for example, is expected to yield 37 500 GEL (5 Tetris per cubic meter).

The economic analysis also assumed the following:

- The system operates for 20 years;
- There is no growth in the volume of wastewater to be treated (O&M costs are considered constant throughout 20 years);
- Capital costs, O&M costs and cost savings are VAT exclusive;
- Standard conversion factor of 0.8 was applied; and
- Costs are given in constant 2004 year prices.

The economic analysis shows that the economic internal rate of return (EIRR) for various systems – treating 5 000 m^3 of wastewater daily during 21 years (1 year of construction and 20 years of operation) – would range from 4% to as high as 60% (see Table 18 below). It should be noted that as only two possible benefits (increased tourism and water for irrigation) could be calculated in monetary terms, the rates of return are likely to be substantially higher.

Table 18. Economic Rate of Return for Treating a Volume of 5 000 m^3 of Wastewater

Technologies	Natural Systems with Lining	Natural Systems without Lining
Lagoon	22%	60%
Recirculating sand filter	4%	5%
Sub-surface flow wetland	7%	10%
Mechanical/package treatment plant	9%	9%

Source: Own estimates.

Lagoon systems have the highest economic rate of return due to their low construction costs (three times less than other natural treatment technologies). If land availability is an issue, then the most economically attractive option is mechanical treatment plants that have 9% of EIRR.

Financial aspects

The financial return has not been estimated because the report assumes that given the current conditions in Georgia, the charges will likely be set at a level to just cover investment and operational costs.

Institutional issues

As stated in the overview of the wastewater sector, wastewater treatment companies are owned by the state through the Agency for State Property Management. These companies, in turn, own the wastewater treatment facilities and are allowed to carry out commercial activities and generate profit. However, tariffs need to be submitted to local authorities and approved by them. Also, due to the low level of tariff collection (25% on average nationwide), these companies in reality often receive subsidies from municipalities and the central government.

Municipalities are supposed to facilitate investments in the water supply and sanitation sector so that water quality standards are met. They are also supposed to supervise the activities of water supply and wastewater treatment companies. At the national level, the supervision of wastewater sector operations is the responsibility of Geowatercanal.

Joint billing for water supply and wastewater treatment services is recommended, but this requires commercial agreements between water supply and wastewater treatment companies. In Tbilisi, for example, a commercial agreement was signed between AES Telasi and Tbilwatercanal in 2004 and now there is joint billing for three items – water, wastewater services and electricity. It is expected that this will lead to an increase of the collection rate for water and wastewater services, and a decrease of the administrative costs of tariff collection.

Risk analysis

Most of the risk factors discussed in Section 3.1.10 are also applicable to this category of projects, but the likelihood of their occurrence and scale of impact are different. The main risk factors identified for the current category of projects are the following:

Risk Factor 1: Level of infrastructure development for onsite management systems – HIGH RISK.

At present, the infrastructure for small-scale decentralised wastewater management systems is underdeveloped because:
- There is very little or no experience in Georgia in designing, constructing and managing onsite wastewater treatment systems, with the exception of mechanical treatment plants.
- Georgian scientists and engineers are not experienced in designing onsite systems and therefore favour centralised wastewater management systems.
- Existing wastewater utility agencies do not have the necessary skills and equipment to maintain and supervise the systems.
- Most of the hauling vehicles that remained from Soviet times, and were used for pumping sewage from individual residences, are obsolete; new hauling vehicles are necessary for pumping septage and sludge from septic tanks and lagoons.
- At present, there are no legal provisions that regulate the proper installation, functioning and inspection of such systems.

Consideration of the above issues is very important in order to avoid improper maintenance of the systems, which may in turn affect further dissemination of alternative technologies in years to come.

Mitigation measures:

- Formulate capacity building activities to ensure appropriate technical and financial management of the systems;
- Prompt necessary policy, institutional and legal reforms so that policies for achieving better control over decentralised systems can be developed and implemented;
- Provide technical assistance for newly established utility companies or existing utility agencies in order to develop appropriate project and operational management skills for staff in wastewater enterprises; and
- Train and educate local officials so that they can offer their support in the implementation of projects.

Risk Factor 2: Existence of demand for the projects – MEDIUM RISK.

Because laws on paying pollution charges are not enforced in most cases, the demand for wastewater treatment is likely to be low in the 22 communities that have sewerage systems and meet criteria for implementing DFES supported projects. However, there is demand to improve water and sewerage infrastructure and the Municipal Development Fund and the Social Investment Fund, together with municipalities, can provide co-financing for these types of projects. Thus far, there has been no co-financing for the installation of wastewater treatment plants by these agencies.

Mitigation measures:
- DFES investments in wastewater treatment can be linked to the improvement of water and sewerage infrastructure, provided that the above two agencies impose the conditionality that collected wastewater be treated as well;
- Local authorities should collect charges for the pollution that water and wastewater utility companies create.

Risk Factor 3: Acceptability of the technology. From LOW to HIGH RISK, depending on the technology.

Because some of the natural treatment technologies may cause odour and other nuisances, such as mosquitoes, the public may be against constructing them. The risk may be high with surface flow wetlands and anaerobic lagoons; as to the other natural treatment technologies, the risk is likely to be minimal.

Mitigation measures:
- The risk can be reduced by installing the technologies that cause minimal nuisances.

Risk Factor 4: User support (contribution) and participation – LOW RISK.

Projects in this category may require co-financing, either in the form or cash, labour, and/or locally available materials. Such types of projects usually have a community mobilisation component. Low user participation may have an impact on the timely completion of the projects.

Mitigation measures:
- Conduct information and awareness building/educational programmes to ensure the involvement of beneficiaries, and foster the co-operation potential between people, and general acceptance; and
- Set certain criteria which would have to be met by sub-projects; e.g. beneficiaries would have to fulfil certain criteria (e.g. community involvement) to be included in the programme.

Risk Factor 5: Affordability of O&M costs – from LOW to HIGH RISK, depending on the technology and the community under consideration.

The financial and economic analysis showed that the cost of wastewater treatment per person per month may range from about 14 Tetris to 81 Tetris, depending on the technology used. According to the O&M cost estimates, the cost of wastewater treatment by natural systems does not exceed 26 Tetris, whereas treatment at a mechanical treatment plant is three times more expensive. If we consider the maximum cost of treatment using natural systems (26 Tetris), then for a family of four, the cost will be about GEL 1. If we add the cost of wastewater collection and of drinking water provision (maximum 1.2 GEL per person), then the combined water and wastewater bill can range from GEL 5 (for natural treatment systems) to GEL 8 (for a mechanical treatment plant). Taking into account that on average Georgian households in rural communities in 2001 had GEL 122 of cash income per month (total income is GEL 195, Source: Georgian Households 1996-2001, SDS), then the water and wastewater bill may represent 4% of that income for natural treatment systems, and 6.5% for mechanical treatment plants. In urban areas, including towns where decentralised treatment systems can be implemented, the average household monthly cash income is

GEL 174. In this case, the combined water and wastewater bill may constitute 2.9%-4.6% of the household budget. If the household budget is tight, then this percentage will indeed matter.

Mitigation measures:
- The risk for community wastewater treatment projects can be reduced if local authorities are willing to either: a) charge community members the real cost of water and wastewater treatment, or b) provide subsidies for the systems in operation.

Risk Factor 6: Willingness to pay – HIGH RISK.

Under the project "Water Management in the South Caucasus" (financed by the USAID), a survey on water and wastewater services was conducted in 2003 in Telavi (population of 25 000). It showed that 62% of the population would be willing to pay increased fees for an improved water supply. A survey conducted in Dmanisi found that 63% of the population found the existing water fee of 20 Tetris acceptable, while 27% of respondents declared that the fee should be lower. In Gurjaani (population of 14 000), the existing fee of 90 Tetris was considered acceptable for only 32% of the population. The surveys showed that even with low tariffs for water services, satisfaction with the level of water tariffs was low. Moreover, about a third of the Telavi community members were not willing to pay increased fees, even with the improvement of water services. However, the situation may be different in other parts of Georgia.

Dissatisfaction with the level of charges could be partly due to the lack of understanding of the system's operation and maintenance costs. People fail to understand why they should pay for water. As a result, the tariff collection rates rarely exceed 50%. The general opinion is that Georgia has abundant water resources and that the state should provide it for free, as in Soviet times. People in general give little value to water as a resource, partly because the resource is not priced. Water left running and the lack of repairs of leaking taps are common and this, in turn, increases the volume of wastewater to be treated.

Mitigation measures:
- Conduct information and awareness building/educational programmes to foster co-operation between people, and general acceptance of combined water/wastewater tariffs; and
- Increase public awareness (through information programmes) about the cost of providing water and sanitation services. The implementation of this public awareness campaign would cost about GEL 0.5 million (preparation of brochures, posters, TV programmes and their broadcasting, etc.). This may increase the combined water tariff collection rates and provide savings on water supply costs, as well as reduce the volume of wastewater to be treated.

Risk Factor 7: Reliability of power supply – from LOW to HIGH risk, depending on the facility.

This risk factor concerns only package treatment plants and recirculating sand filters that require electricity for proper functioning. The risk is low for most of the natural treatment systems, as well as for the facilities located near mini hydropower plants.

Mitigation measure:
The risk can be minimised by adding generators to the treatment systems. However, this could increase significantly the cost of treatment. An alternative option would be to enter into direct power purchase agreements with power plants nearby.

Risk Factor 8: Ability to maintain the system – LOW RISK.

Maintenance requirements for natural treatment systems are low and they do not require professional staff to operate them. However, if the systems are improperly managed, failures may occur.

Mitigation measures:
- It is important to develop a set of rules and regulations by which an agency should operate the treatment systems; and also provide training for personnel;
- Once the systems have been installed, a routine monitoring schedule must be set up to ensure the long-term performance and reliability of these systems.

3.3. Project Category 3: Rehabilitation of Large Centralised Wastewater Management Systems

Background and rationale

As mentioned in the overview of the wastewater sector of Georgia, large centralised treatment plants work only in the cities of Tbilisi-Rustavi, Kutaisi, Batumi, Khashuri and Gori. Currently, only primary treatment works, and this to a limited degree. Secondary treatment facilities have collapsed.

As a result, partially treated wastewater is discharged into surface waters. This is a threat to public health and a cause of tension between Georgia and Azerbaijan. Approximately 612 000 m^3/d of unsatisfactorily treated effluent is discharged from the Gardabani treatment plant – which serves the cities of Tbilisi and Rustavi – into the Kura River at a point 20 km from the border with Azerbaijan. For this country the Kura River is an important source of drinking water.

Objectives

- Eliminate a source of tension between Georgia and Azerbaijan;
- Improve environmental, sanitary and health conditions;
- Provide opportunities for generating economic benefits from reuse and recycling; and
- Decrease pollution of international water bodies.

Beneficiaries

The beneficiaries include municipalities and wastewater utility companies.

Investment cost estimates

The investment costs for rehabilitating the existing Gardabani treatment plant are based on the rehabilitation needs of primary and secondary treatment facilities. These estimates were made by engineers and economists at Geowatercanal and are presented in the tables below.

Table 19. Investment Costs for the Rehabilitation of Gardabani's Primary Treatment Unit (USD)

Facilities to be Rehabilitated	Costs
Wastewater distribution tank	8 000
Bar racks for course screening	90 000
Horizontal flow grit chamber	25 000
Primary radial flow sedimentation tanks (8)	1 000 000
Distribution tank for primary sedimentation tanks (3)	5 000
Sludge pumping stations (3)	130 000
Three unit pumping station	60 000
Emergency discharge collector	400 000
Grit disposal field	5 000
Sludge disposal field	70 000
Water supply system	17 000
Collector system	90 000
Administrative building / Laboratory	80 000
Power receiving station	200 000
Fencing the territory	50 000
Trucks and special equipment.	100 000
Total	*2 330 000*
VAT	466 000
Grand Total	**2 796 000**

Source: Geowatercanal.

Table 20. Investment Costs for the Rehabilitation of Gardabani's Secondary Treatment Unit (USD)

Facilities to be Rehabilitated	Costs
Aeration tanks (8)	2 000 000
Activated sludge pumping station	30 000
Air pumping station	50 000
Air chamber	50 000
Methane tanks (6)	400 000
Emergency discharge unit	500 000
Sludge dewatering unit	60 000
Effluent discharge unit	50 000
Secondary radial flow sedimentation tanks (10)	1 000 000
Heat generation station	160 000
Access road	50 000
Fencing of the territory, lights	50 000
Equipment for the laboratory	50 000
Total	*4 450 000*
VAT	890 000
Grand Total	**5 340 000**

Source: Geowatercanal.

In total, rehabilitation of both primary and secondary treatment units would cost USD 8 136 000. The investment can be phased over six to eight years.

Operation and maintenance cost estimates

Geowatercanal staff have also provided operation and maintenance cost estimates, which are presented in Table 21. These estimates are based on manpower, energy and other requirements of primary and secondary treatment systems, and on the assumption that approximately 150 staff will be employed by the treatment facility and that energy consumption will be approximately 6 600 kW/h.

Table 21. Operation and Maintenance Costs of the Gardabani Treatment Plant (GEL/Year)

Budget Item	Costs
Salary fund	700 000
Taxes on salary fund (31%)	217 000
Energy	4 640 000
Other operation expenses	205 000
Repair of the system	200 000
Amortisation	400 000
Per-diems	20 000
Communal services	28 000
Chemicals for laboratory analysis	20 000
Office expenses	24 000
Other expenses	50 000
Total	6 504 000
12%	780480
Total without VAT	**7 284 480**

Source: Geowatercanal.

Treatment unit costs

The Gardabani treatment plant currently receives 612 000 m^3/d of wastewater. If the cost of secondary treatment is included, then the per unit cost would be 3.2 Tetris/m^3. This means that if an individual in Tbilisi generates 200 litres of wastewater daily, she/he would be paying 20 Tetris/month for treating wastewater. At present, she/he pays approximately 4 Tetris/month.

A cost-benefit analysis has not been done for Gardabani. Located about 40 km from the border with Azerbaijan, the main benefits of the Gardabani treatment plant accrue to Azerbaijan and not to Georgia. An economic analysis would have been justified if undertaken at a regional level.

Risk analysis

Risk Factor 1: Level of infrastructure development for centralised management systems – LOW RISK.

The infrastructure for centralised management systems is well developed – there are scientists and engineers experienced in designing and constructing mechanical wastewater treatment plants; the existing plants are staffed with experienced personnel and operate under set rules and regulations. However, most of the rules and regulations date back to Soviet times and might need revision.

Risk Factor 2: Existence of demand for the rehabilitation of the systems – NO RISK.

Rehabilitation of wastewater treatment plants, especially of the Gardabani regional treatment plant, is considered a priority in the National Environmental Action Plan. Until now the government has been trying (unsuccessfully) to attract investment for rehabilitation.

Risk Factor 3: Acceptability of the technology – NO RISK.

Risk Factor 4: User support and participation – NOT APPLICABLE.

Rehabilitation work requires skilled workers.

Risk Factor 5: Affordability to pay O&M costs – MEDIUM RISK.

It has been shown above that with secondary treatment of wastewater, the bill will increase by 16 Tetris; that is, for a family of four, the combined water/wastewater bill will come to about GEL 5.5, which constitutes 2.9%-4.6% of a family's budget in large cities. This can be a noticeable percentage when family budgets are tight. Besides, with the introduction of joint billing for water, wastewater and electricity, the tariff collection rate is expected to increase.

The sustainability of investments at Gardabani depends on the willingness of local authorities to price wastewater treatment at its real cost. At present, the tariff would cover barely 20% of costs. Unless the present tariffs are corrected, or long-term sources of subsidies ensured, investments in Gardabani would not be sustainable.[65]

Risk Factor 6: Reliability of power supply – LOW RISK.

The Gardabani treatment plant is located near an electricity generation station.

Risk Factor 7: Ability to maintain the system – NO RISK.

The system is run by professional personnel.

4. SUMMARY AND CONCLUSIONS

This section summarises the results of the analysis for all three project categories under the wastewater management pipeline, and draws conclusions about the introduction and implementation of these projects.

Project Categories

Project Category 1: Onsite wastewater management in *unsewered areas*.
Project Category 2: Wastewater management for *small communities with sewerage system.*
Project Category 3: Rehabilitation of centralised wastewater management systems in large settlements.

The first two categories of projects are decentralised wastewater management systems. These refer to small discharges of wastewater that can be treated using natural treatment systems, such as lagoons, sand filters, constructed wetlands, etc. The third category of projects refers to large discharges of wastewater where the only option for wastewater treatment is a mechanical treatment plant.

The current analysis considered five main criteria for project selection and prioritisation, which are summarised below.

Criterion 1. Size of Investments

[65] Sustainability of investments can also be enhanced by entering into cost sharing agreements with Azerbaijan, the main beneficiary of improved water quality from Gardabani.

Table 22 summarises the investment costs for all three categories of projects, while Table 23 gives estimates of the number of projects that can be implemented under each project category with USD 1 million (GEL 1.9 million) financing. It can be seen that the investment costs for the first category of projects fall well below the expected size of DFES funds, hence a large number of projects can be implemented. The second category of projects is also within the range of DFES funds, with the exception of projects that can be phased over 2 years. As to the third category of projects, rehabilitation of Gardabani, the largest functioning treatment plant in Georgia, can be phased over 8 years. Therefore, if we consider only this criterion (i.e. investment costs), all three categories of projects can be implemented.

Table 22. Investment Costs (GEL)

Technology	Wastewater Flow Rate (m^3/d)					
	10	100	1 000	2 500	5 000	612 000
	Category 1		Category 2			Category 3
Lagoon	22 573	110 210	133 466	308 357	616 714	-
Intermittent sand filter	40 440	*Not recommended*				-
Recirculating sand filter	34 131	180 520	869 873	2 054 903	4 109 806	-
Sub-surface flow wetland	27 523	166 883	705 398	1 710 719	3 421 439	-
Mechanical/biological treatment plant	35 000	190 000	825 000	1 050 000	1 500 000	15 539 760

Source: Own estimates.
Note: Costs are without lining requirements for natural systems.

Table 23. Number of Projects that Can Be Implemented in One Year with 1.9 mln GEL Financing

Technology	Wastewater Flow Rate (m^3/d)					
	10	100	1 000	2 500	5 000	612 000
	Category 1		Category 2			Category 3
Lagoon	85	17	14	6	3	-
Intermittent sand filter	47	*Not recommended*				-
Recirculating sand filter	56	11	2	1	1 project phased over *2* years	-
Sub-surface flow wetland	69	11	3	1	1 project phased over *2* years	-
Mechanical/biological treatment plant	55	10	2	2	1 project phased over *2* years	Gardabani project phased over *8* yrs

Source: Own estimates.

It should be noted that Table 23 above provides a technical estimate. The real total size of the project pipeline, however, is difficult to estimate as there is, at present, almost no demand for small and medium decentralised systems. This is so because maximum allowed discharges are insufficiently enforced, thus precluding private investment, and because municipalities lack resources to rehabilitate or construct new systems.

Criterion 2. Cost-effectiveness – volume (m^3) of wastewater treated per unit of dollar invested.
Table 24 below presents a summary of the per unit costs of wastewater treatment using various technologies at different wastewater flow rates. It can be seen from this table that because of economy of scale, the cost of treatment for a specific technology decreases with an increase in wastewater flows. Therefore, maximum effect in terms of pollution reduction per unit of dollar invested is likely to be achieved for larger wastewater flows.

Table 24. GEL per m^3 of Wastewater Treated (Based on O&M Costs)

Technology	Wastewater Flow Rate (m^3/d)				
	10	100	1 000	5 000	612 000
Lagoon	0.114	0.061	0.028	0.023	Not applicable
Intermittent sand filter	0.080				Not applicable
Recirculating sand filter	0.154	0.053	0.043	0.038	Not applicable
Sub-surface flow wetland	0.097	0.044	0.023	0.011	Not applicable
Mechanical/biological treatment plant	0.562	0.145	0.136	0.134	0.032

Source: Own estimates.

Note: The cost of treatment for the Gardabani treatment plant (serving Tbilisi and Rustavi) also includes the cost of secondary treatment.

Tables 25 and 26 address the question of whether it is more cost efficient to invest in a single large project or in several smaller ones.

Table 25. Investment Cost Required to Match Flow Rates at Gardabani

	Wastewater Flow Rate (m^3/d)				
	10	100	1 000	2 500	5 000
Number of units required to match outflow at Gardabani	61 200	6 120	612	245	122
	Investment required to match outflow at Gardabani (GEL)				
Lagoon	1 381 467 600	674 485 200	81 681 192	75 485 794	75 485 794
Intermittent sand filter	2 474 928 000	*Not applicable*			
Recirculating sand filter	2 088 817 200	1 104 782 400	532 362 276	503 040 254	503 040 254
Sub-surface flow wetland	1 684 407 600	1 021 323 960	431 703 576	418 784 011	418 784 134
Mechanical treatment plant	2 142 000 000	1 162 800 000	504 900 000	257 040 000	183 600 000

Source: Own estimates.

Table 25 above compares the investment costs for decentralised and centralised technologies in order to achieve the rate of treatment of the wastewater flow similar to that of Gardabani. For example, if all DFES resources were invested in plants with a maximum flow rate of 100 m^3/day, there would be a need for 6 120 of these decentralised units. If all of these units were of the lagoon type, then the total investment costs would be approximately GEL 674 million. For Gardabani, the investment required to treat the same amount of wastewater is GEL 15.5 million. The main conclusion from Table 25 is that, provided resources are available, it would be advisable to invest the bulk of resources in a large treatment plant.

A similar result can be obtained by comparing the cost of treating the daily wastewater flow rate from Gardabani, but using decentralised wastewater treatment options. Table 26 shows the daily costs of treating 612 000 m^3/day using units with flow rates of 10, 100, 1 000 and 5 000 m^3/day.

Table 26. Cost of Treating 612 000 m^3/Day Using Decentralised Technologies (GEL)

	Wastewater Flow Rate (m^3/d)			
	10	100	1 000	5 000
Lagoon	69 768	37 332	17 136	14 076
Intermittent sand filter	48 960	*Not applicable*		
Recirculating sand filter	94 248	32 436	26 316	23 256
Sub-surface flow wetland	59 364	26 928	14 076	6 732
Mechanical treatment plant	343 944	88 740	83 232	82 008

For Gardabani, the daily cost of treating 612 000 m^3/day is GEL 19.584. It can be seen that some technologies in Table 26 provide cheaper options, such as sub-surface flow wetlands with a flow rate of 5 000 m^3/day. These gains, however, are not sufficient to counterbalance the difference in investment costs required to build the number of units necessary to match the flow rate at Gardabani.

Criterion 3. Location of the Point Source of Pollution

Here, the question is whether reducing pollution along the Black Sea coast matters more than reducing pollution near the border with Azerbaijan or at points in between. The answer depends on factors outside the scope of this report. From a donor's point of view, cities located along the Black Sea coastal area and the urban cluster of Tbilisi-Rustavi may matter more than small settlements in between. The reason for this is because those in the coastal belt discharge directly into the Black Sea, an international water body, and Tbilisi-Rustavi is the main point of pollution of the Kura River, affecting the water supply of Azerbaijan and contributing to cross-border tensions. From a national perspective, towns along the Black Sea coast and settlements higher up along the Kura River would matter more. First because improved water quality will have an impact on tourism revenues for towns along the Black Sea and, second, treating wastewater discharge from towns located along the upper sections of the Kura River will have a cumulative effect downstream, decreasing the costs of water treatment and diminishing the negative impact of water-borne diseases. All these issues should be discussed between the Government of Georgia and donors as part of the process of establishing DFES.

Criterion 4. Risk

Most of the issues for this criterion were discussed under the risk analysis for each project category. Table 27 below summarises the risk analysis for all project categories. The first four factors deal with the feasibility of the projects, while the last three factors concern the sustainability issues that will be discussed later.

Table 27. Summary of Risk Analysis

Risk Factors	Category 1			Category 2			Category 3		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
1. Level of infrastructure development			√			√	√		
2. Existence of demand for projects			√		√		-	-	-
3. Acceptability of the technology (1)	√	√	√	√	√	√	-	-	-
4. User support and participation	√			√			-	-	-
5. Affordability and willingness to pay O&M expenses (2)	√	√	√	√	√	√		√	
6. Reliability of power supply (3)	√	√	√	√	√	√	√		
7. Ability to maintain the system	√			√			-	-	-

Source: Own estimates.

Notes:

(1) Risk can vary from low to high depending on the technology used.

(2) Risk can vary from low to high depending on the technology used.

(3) Risk can vary from low to high depending on the technology used.

Table 27 shows that projects under decentralised management (Categories 1 and 2) have higher risk factors than projects under centralised management (Category 3). This is mostly because there is almost no experience in Georgia with using alternative wastewater treatment technologies.

Although a cost-benefit analysis was conducted for only Category 2 projects, it is useful for comparing different technologies. It should be noted, however, that all capital and operation and maintenance costs given in this report are average costs (actual costs may vary by 20%, depending on the site) and are used for comparative purposes.

This report has shown that under decentralised wastewater management, lagoons have the least capital investment requirements and the highest economic internal rate of return. When land availability is not an issue, the lagoon technology is likely to be the preferred option for wastewater treatment. Moreover, the EIRR was positive for all technologies, even when not all benefits were monetised.

Criterion 5. Sustainability (in terms of the feasibility of charging the true cost of wastewater treatment, and the affordability and willingness to pay O&M expenses, the ability to maintain the system, and the reliability of the power supply (summarised in Table 27, Factors 5-7).

The feasibility of charging the true cost of wastewater treatment depends on the will of local authorities in the city or town in question. If political will is there, big urban settlements may have a greater capacity than smaller settlements to increase collection rates, for example, by tying the electricity bill to water supply and water treatment charges, like in Tbilisi. Smaller settlements may lack this option. Having said that, it is by no means ensured that bigger settlements will indeed show a greater willingness to cover the true costs of wastewater treatment.

In view of the above, this report reaches the following conclusions:

- If DFES resources for the wastewater management pipeline can go as high as GEL 15.5 million over 4 or 8 years, *and if benefits from a regional perspective are taken into account*, then it would be advisable to invest this amount in the rehabilitation of the Gardabani plant, because:
  - It achieves the maximum reduction in the level of pollution per unit of dollar invested.
  - It will reduce tensions between Georgia and Azerbaijan.
  - The sustainability of investment could be ensured as Tbilisi and Rustavi have greater means to charge the true costs of water treatment. Georgia could also enter into cost-sharing agreements with Azerbaijan, the primary beneficiary of investments in Gardabani. (This option exceeds the scope of the analysis of this report and therefore has not been further explored.)
- If settlements along the Black Sea coastal area and those along the upper section of the Kura River are prioritised, the same amount (GEL 15.5 million) could be alternatively invested in treatment units of 5000 m^3/day in settlements with an established sewerage network. This option results in a greater amount of wastewater being treated than with an equivalent investment in smaller units.
- For smaller amounts available under a DFES programme, onsite decentralised management options become the preferred choice.
- There can be a mix of project categories in case DFES has sufficient funds.

7. REFERENCES

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