

**Chapter 13 PV Rural Electrification Project Planning
Model and Financial/Economic Analysis**

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13.1 Project Model

13.1.1 Objective of the Project Model

Various factors required for PV rural electrification are clarified in successive chapters. It is necessary for the Implementation Body to formulate the business plan for PV rural electrification as described in Chapter 12, taking them into consideration.

A project model is elaborated, based on the results of the study for the purpose of pre-feasibility study. The financial and economic analyses reveal the required conditions in order for the Implementation Body to operate the business on a sustainable basis.

13.1.2 Project Model

(1) Target villages and localities and PV electrification schedule

Selection of villages and localities for PV electrification is discussed in Chapters 6 and 7. Then, priority setting for target villages and localities is made in Chapters 7. As a result, the following framework was established for project modeling.

- 1) The entire country is divided into six zones (Zones 1 through 6) to conduct PV electrification for more or less the same number of villages and localities in each zone over the ten-year period.
- 2) The BCS system will be installed in parallel with the SHS installation in villages and localities with more than 500 population in order to facilitate the use of service by low income households, thereby to increase the PV electrification rate.

Within the framework, sensitivity analysis was conducted by varying relevant factors. Table 13.1-1 shows the detailed breakdown of target villages for PV electrification (SHS and BCS). Note that population data are based on the results of the 2001 Census.

Table 13.1-1 PV Electrification Plan

1) Number of Villages/Localities for PV Electrification

	Installation Year	1	2	3	4	5	6	7	8	9	10	Total
Zone1	Ngwaketse	4	3	2	5	1	1	3	6	3	3	31
	Barolong	2	2	3	1	2	6	2	1	4	4	27
	Ngwaketse West	0	1	0	0	1	0	1	0	0	0	3
	South East	0	0	1	0	2	0	1	0	0	0	4
Zone2	Kweneng East	0	1	3	2	5	2	3	3	4	3	26
	Kweneng West	5	3	2	2	0	1	2	1	1	1	18
	Keatleng	0	1	0	1	0	2	0	1	0	1	6
Zone3	North East	0	1	4	1	2	2	0	0	0	1	11
	Scrowe/Palapye	2	3	1	3	2	2	2	4	4	1	24
	Bobonong	3	1	0	1	1	1	3	1	1	3	15
Zone4	Mahalapye	1	2	3	2	3	0	1	0	1	2	15
	Boteti	0	0	2	0	0	0	1	1	0	2	6
	Tutume	5	4	1	4	3	6	4	5	5	3	40
Zone5	Ngamiland East	0	3	5	3	3	4	3	1	3	3	28
	Ngamiland West	6	3	2	3	2	3	3	5	4	3	34
	Chobe	0	0	0	0	1	0	1	0	0	0	2
	Delta	0	0	0	1	1	0	0	1	0	1	4
Zone6	Ghanzi	1	0	1	0	2	1	2	1	0	1	9
	Kgalagadi South	1	0	1	0	0	0	0	1	1	1	5
	Kgalagadi North	0	2	0	2	0	1	0	0	1	1	7
	合計	30	30	31	31	31	32	32	32	32	34	315

2) Population and Numer of Households in Villages/Localities to be PV-Electrified

Zone1	Village	6	5	3	2	2	6	3	2	6	2	37
	Locality	0	1	3	4	4	1	4	5	1	5	28
	Total	6	6	6	6	6	7	7	7	7	7	65
	Village Population	4150	3196	1462	1084	673	2158	536	706	1483	253	15701
	Locality Population	0	621	1219	985	1038	309	1662	1409	238	1217	8698
	Total Population	4150	3817	2681	2069	1711	2467	2198	2115	1721	1470	24399
Zone2	Village	4	4	0	1	0	4	2	3	2	0	20
	Locality	1	1	5	4	5	1	3	2	3	5	30
	Total	5	5	5	5	5	5	5	5	5	5	50
	Village Population	2590	1637	0	464	0	1246	95	711	489	0	7232
	Locality Population	2585	559	2138	1379	1273	355	1113	736	982	1077	12197
	Total Population	5175	2196	2138	1843	1273	1601	1208	1447	1471	1077	19429
Zone3	Village	5	5	3	3	5	1	0	0	0	1	23
	Locality	0	0	2	2	0	4	5	5	5	4	27
	Total	5	5	5	5	5	5	5	5	5	5	50
	Village Population	3784	2146	1133	949	1363	318	0	0	0	182	9875
	Locality Population	0	0	661	641	0	1161	1669	1792	1388	959	8271
	Total Population	3784	2146	1794	1590	1363	1479	1669	1792	1388	1141	18146
Zone4	Village	5	6	4	6	1	1	0	0	2	0	25
	Locality	1	0	2	0	5	5	6	6	4	7	36
	Total	6	6	6	6	6	6	6	6	6	7	61
	Village Population	5400	3644	2186	3126	205	424	0	0	336	0	15321
	Locality Population	3052	0	1106	0	2562	2145	1497	2354	1372	1633	15721
	Total Population	8452	3644	3292	3126	2767	2569	1497	2354	1708	1633	31042
Zone5	Village	5	2	5	2	2	0	2	3	1	2	24
	Locality	1	4	2	5	5	7	5	4	6	5	44
	Total	6	6	7	7	7	7	7	7	7	7	68
	Village Population	2633	839	1512	332	684	0	696	650	194	253	7793
	Locality Population	732	1858	687	1398	1697	2425	1694	952	1817	1306	14566
	Total Population	3365	2697	2199	1730	2381	2425	2390	1602	2011	1559	22359
Zone6	Village	2	2	2	2	2	2	1	1	1	1	16
	Locality	0	0	0	0	0	0	1	1	1	2	5
	Total	2	2	2	2	2	2	2	2	2	3	21
	Village Population	949	835	762	659	667	890	331	405	175	172	5845
	Locality Population	0	0	0	0	0	0	245	224	233	511	1213
	Total Population	949	835	762	659	667	890	576	629	408	683	7058
Total	Village	27	24	17	16	12	14	8	9	12	6	145
	Locality	3	6	14	15	19	18	24	23	20	28	170
	Total	30	30	31	31	31	32	32	32	32	34	315
	Village Population	19506	12297	7055	6614	3592	5036	1658	2472	2677	860	61767
	Locality Population	6369	3038	5811	4403	6570	6395	7880	7467	6030	6703	60666
	Total Population	25875	15335	12866	11017	10162	11431	9538	9939	8707	7563	122433

Average Population Increase in 10 Years 1.25 → Yearly Incremental Ratio: 1.0226
 Average Number of a Family 4.48

SHS	No. of HHs in 2001	5,776	3,423	2,872	2,459	2,268	2,552	2,129	2,219	1,944	1,688	27,330
	Population Incremental Ratio from 2001 to Instal. Year	1.0692	1.0934	1.118	1.1433	1.1691	1.1954	1.2224	1.25	1.2782	1.307	
	No. of HHs in Installation Year	6,176	3,743	3,211	2,811	2,651	3,051	2,603	2,774	2,485	2,206	31,711
BCS	No. of Villages/Localities BCS	25	15	6	7	0	4	3	2	0	0	62
	Population	21,404	11,950	3,681	4,152	0	2,508	1896	1,365	0	0	46,956
	No. of HHs in 2001	4,778	2,667	822	927	0	560	423	305	0	0	10,482
	Population Incremental Ratio from 2001 to Instal. Year	1.0692	1.0934	1.118	1.1433	1.1691	1.1954	1.2224	1.25	1.2782	1.307	
	No. of HHs in Installation Year	5,109	2,916	919	1,060	0	669	517	381	0	0	11,571

(2) Electrification Rate

Based on the results of evaluation and analysis in Chapters 6 and 7, the SHS electrification rate (the percentage of households to be electrified using the SHS versus total number of households in the target villages) is assumed to be 40% of all the households in the target villages and localities. In addition, the BCS system will be installed in villages and localities with more than 500 population, covering 20% of all the households in the target villages for BCS electrification.

(3) Electrification Schedule

Village/localities: Target villages and localities will be electrified during the period from the first year to the tenth year. However, actual installation in a village will be done for 3 years:

In the first year : 35% of the target households to be PV electrified

In the second year : 40% of the target households

In the third year : 25% of the target households

The yearly change in the number of villages/localities electrified by the PV system is summarized in Figure 13.1-1. The yearly change in the number of households electrified with SHS/BCS is shown in Figure 13.1-2.

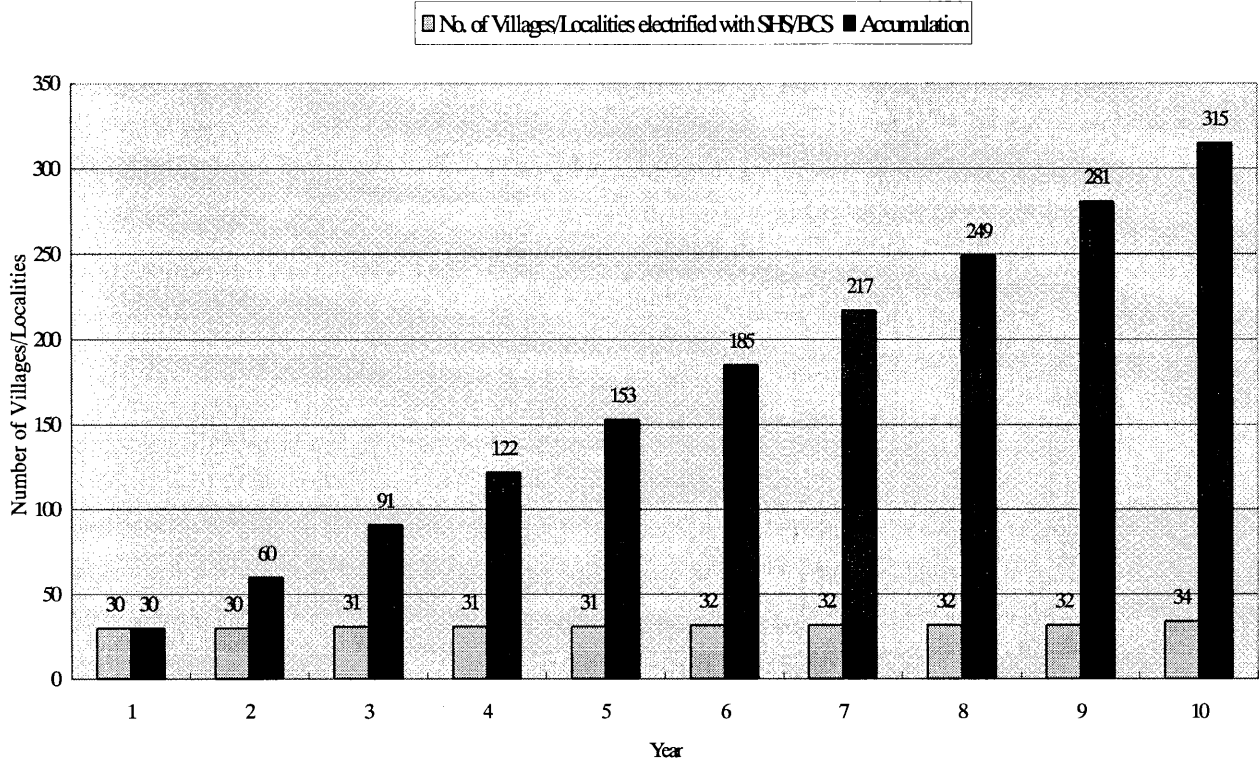


Figure 13.1-1 No. Of Villages and Localities PV Electrified (Base Case: SHS/BCS:40/20%)

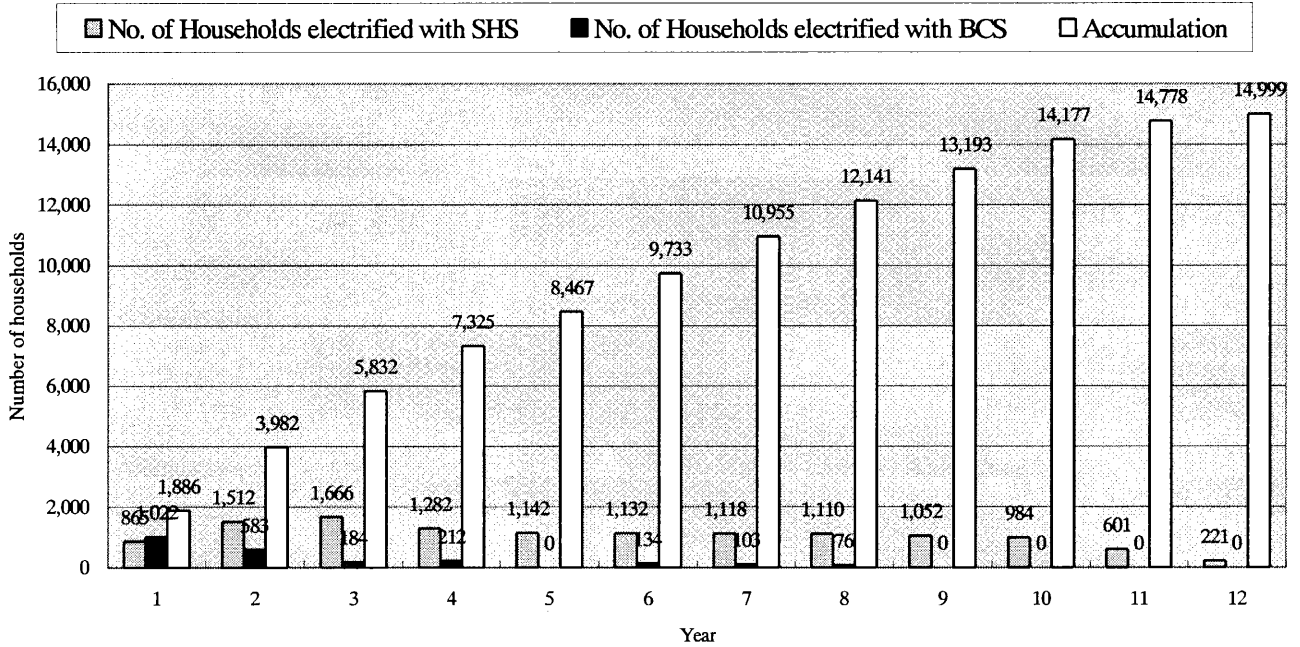


Figure 13.1-2 Number of Households Electrified with SHS/BCS (Base Case: SHS/BCS:40/20%)

(4) PV system capacity

Based on the average PV demand per household and the average capacity demand by public facilities estimated in Chapter 6 and 7, the total installed PV capacity was estimated for each of the cases assumed in 13.1(2). The bases are as follows.

- 1) The average PV capacity demand per household is assumed to be 68Wp.
- 2) For public facilities, capacity demand is assumed to be 1,650Wp for villages and 350Wp for localities.

(5) Investment Cost

The following is the basis of investment cost based on the results obtained in the Dissemination Project (standard cost). (Refer to Appendix 15.5 and 15.7)

1) SHS : Panel 50Wp is assumed as a unit for SHS

Battery : 102 Ah

SHS 50Wp: P4,500/system

SHS 100Wp: P9,000/system

SHS 150Wp: P13,500/system

SHS 200Wp: P18,000/system

SHS 250Wp: P22,500/system

2) Centralized PV System : 500Wp as a unit (for public facilities)

P45,000/unit

3) BCS : 500Wp as a unit

Battery for user : 30 Ah

User coverage/system : 30 households/system (BCS: 500Wp)

The number of BCS users is assumed to be 40% of the SHS users.

BCS (500Wp) : P97,650/system

Battery for BCS user : P1,400/system (including one complete spare per a user)

4) Replacement of system components

* Battery:

SHS : P500/Battery (every 3 years)

BCS user : P245/Battery (every 3 years)

* Controller

SHS : P500/50Wp system (every 10 years)

BCS user : P200/BCS user (every 10 years)

5) Land cost: To be leased with free of charge

6) Building: To be leased at P50/m/person (estimate)

(6) Funding arrangement

Equity: 20% of equipment investment

The capital is to be applied to equipment investment during the first 12 years after commencement of the nationwide project. PV system costs and replacement costs of batteries and controllers are included in the equipment investment.

Subsidy: Subsidy for equipment investment to be considered. Analysis is conducted by varying subsidy ratios for the assumed investments.

Loan: Bank loan is to be arranged for the balance portion of equipment investment and the equity and the subsidy. Interest rate is 14%.

Capital increase for deficit:

The capital increase is to be considered and arranged when cash flow is expected to become negative.

(7) Revenue

As set in Section 9.3 of Chapter 9, the standard tariff system is assumed as follows:

1) Monthly user charge : SHS 50Wp – P40 /m
Centralized 500Wp – P600/m
BCS batteries – P15/m

2) Security deposit : Three months of user charge (not including BCS users)

- To be allocated to payment of user charge when overdue.
- To be allocated to compensation for an equipment damage attributable the user.
- To be refunded upon termination of the service contract (no interest).

(8) Manpower Requirement and Salaries

The standard wage rates are assumed as follows.

1) Village operation unit (Agent-agreement in every village and locality)

Sales Agent : 1 person

Sales agent is to play a role for both a prepaid card sales agent and a contracting/deposit collecting agent.

Prepaid card agent fee: 5% of total sales

Contracting/deposit collecting agent fee: 10% of deposit collected.

System Monitoring Agent

: 1 person

Agent fee:

50Wp SHS user P7.5/m

100Wp SHS user P10/m

150Wp SHS user P12.5/m

200Wp SHS user P15/m

250Wp SHS user P17.5/m

Over 250Wp SHS user P20/m

BCS (Battery Charging Station) user: 33% of sales

Note: the minimum salary is P300/m.

2) Implementation Body

Manpower requirements are estimated for the head office and local offices.

Table 13.1-2 shows the manpower requirement for the Implementation Body and villages and localities. The manpower requirement shown in Table 13.1-2 includes sum of part time works such as for commercial officers of regional offices.

Salaries for the head office personnel

Director : P10,000/m

Senior Officer : P7,000/m

Officer : P4,000/m

Assistant : P2,000/m

Miscellaneous : P1,000/m

Salaries for the local office personnel

Maintenance Engineer	: P5,000/m
Officer	: P4,000/m
Technician	: P2,000/m
Assistant	: P1,000/m

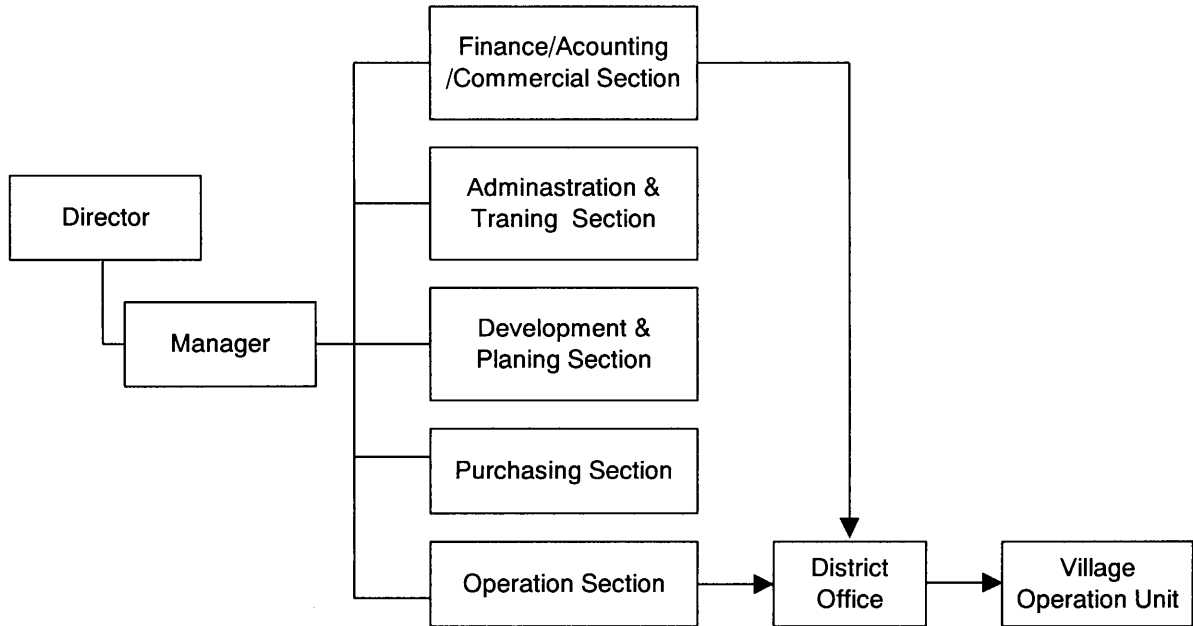


Figure 13.1-3 Organization

(9) General expenses: 50% of labor cost of the Implementation Body

The detailed assumptions for the project model are described in Appendix 13.

Table 13.1-2 Manning Schedule

(Electrification Rate%: SHS/BCS:40/20)

MANNING (Year)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Village Operation Unit																					
Sales Agent	30	60	91	122	153	185	217	249	281	315	315	315	315	315	315	315	315	315	315	315	315
System Monitoring Agent	30	60	91	122	153	185	217	249	281	315	315	315	315	315	315	315	315	315	315	315	315
Village Total	60	120	182	244	306	370	434	498	562	630	630	630	630	630	630	630	630	630	630	630	630
Head Office																					
Director	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Finance/Account/Commercial Section																					
Accountant	1	1	1	1	2	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Finance Officer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Commercial Officer	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Assistant	0	0	0	0	0	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2
Administration & Training Section																					
Officer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Assistant	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Development & Planing Section																					
Officer	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Purchasing Section																					
Officer	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Assistant	1	2	2	1	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0
Operation Section																					
Officer	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Assistant	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2
Miscellaneous Labor	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Head Office Total																					
Total No. of Director	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total No. of Manager	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Total No. of Officer	6	6	6	6	7	6	6	6	6	6	8	8	7	7	7	7	7	7	7	7	7
Total No. of Assistant	3	4	4	3	3	4	4	4	5	5	6	6	5	5	5	5	5	5	5	5	5
Miscellaneous Labor	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Total Head office	12	13	13	12	14	14	14	14	15	15	19	19	17	17	17	17	17	17	17	17	17
Regional Office																					
Maintenance Section																					
Leading technician	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Assistant technician	6	6	6	6	6	6	6	6	6	6	6	6	6	6	0	0	0	0	0	0	0
Commercial Section																					
Officer	2	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Assistant	2	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Miscellaneous Labor	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Regional Office Total																					
Total No of Technician	12	12	12	12	12	12	12	12	12	12	12	12	12	6	6	6	6	6	6	6	6
Total No. of Commercial Officer	2	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Total No of Assistance	2	3	3	3	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1
Total No. of Miscellaneous Labor	1	1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3
Total District Office	17	19	19	19	18	18	18	18	18	18	19	17	17	11	11	11	11	11	11	11	11
Implementation Body Total	29	32	32	31	32	32	32	32	33	33	38	36	34	28	28	28	28	28	28	28	28