

Contents Report Volume – I

Foreword
Preface
Check List
Salient Features
Index Map
Executive Summary
List of Officers Associated in Preparation of DPR
Contents

Para No.	Particulars	Page No.
	Chapter – 1 Introduction	
1.0	General	1
1.1	Brief description of the link project	2
1.1.1	Aim and Justification of the project	3
1.2	Location of project area	5
1.3	Communication facilities	8
1.4	General climatic conditions of the state and project area	9
1.5	Topography, physiography and geology of the area	12
1.5.1	Topography/physiography	12
1.5.2	Geology	12
1.6	Population	13
1.7	Natural resources	15
1.7.1	Water resources	15
1.7.2	Land resources	15
1.7.3	Agriculture	16
1.7.4	Mineral wealth	17
1.7.5	Industry	17
1.7.6	Tourism	18
1.8	Land use and socio-economic aspects	18
1.8.1	Cropping pattern	18
1.8.2	Socio-economic aspects	19
1.8.3	Drought prone areas	19

Para No.	Particulars	Page No.
1.8.4	Ground water	20
1.8.5	Water quality	20
1.9	Earlier proposals	20
1.10	Present/alternate studies at DPR stage	21
1.10.1	Main components of present proposals	22
1.10.1.1	Bedti (Pattanadahalla, Shalamalahalla) - Varada link project(Link-I)	22
1.10.1.2	Bedti (Suremane) - Dharma link project(Link-II)	23
1.11	Project planning and optimization of benefits and stages/phases of development	23
1.12	Fitment of scheme in overall development of region	23
1.13	Intimation to the other development authorities regarding this scheme	24
1.14	Experiences of Inter-linking of rivers in India	26
1.15	Methodology adopted	27
1.15.1	Surveys & Investigations	27
1.15.1.1	Topographical surveys	27
1.15.1.2	Investigations carried out by other agencies	28
1.15.2	Technical studies	30
1.15.2.1	Hydrological studies	31
1.15.2.2	Irrigation planning and command area	32
1.15.2.3	Design of important project components	33
1.15.2.4	Construction program, manpower and plant planning	36
1.15.2.5	Socio-Economic survey, Environmental ImpactAssessment (EIA) and Environmental Management Plan (EMP)	36
1.15.2.6	Cost estimate	36
1.16	Public announcement and public hearings	37
1.17	Inter-linking of the scheme with neighboring scheme	38
1.18	Inter-state/International aspects	38
1.19	Cost and benefit of the scheme	38
1.19.1	Cost of the project	38
1.19.2	Benefits from the project	39
1.20	Public cooperation and participation	39

Para No.	Particulars	Page No.
1.21	Clearances required	39
	Chapter – 2	40
	Physical Features	
2.0	General	40
2.1	Geographical disposition	40
2.2	Topography of the basins, barrage/weirs and benefitted area	41
2.2.1	Topography and physiography	41
2.2.2	Topography of the command/benefitted area	42
2.3	Geology of the basin/sub-basin and command area	43
2.3.1	Geology of Bedti basin	43
2.3.1.1	Geology of Uttara Kannada district	
2.3.2	Geology of Tungabhadra sub-basin	44
2.3.3	Geology of command area (LBC of Tungabhadra project)	44
2.3.3.1	Geology of Raichur district	45
2.4	River system and catchment area	46
2.4.1	Bedti river	49
2.4.2	Tungabhadra/Varada/Dharmariver	49
2.5	Basin characteristics	50
2.5.1	Bedti basin	50
2.5.1.1	Rainfall	51
2.5.1.2	Temperature	51
2.5.1.3	Relative humidity	51
2.5.1.4	Wind speed	52
2.5.1.5	Cloud cover	52
2.5.1.6	Evaporation	53
2.5.2	Tungabhadra sub-basin	53
2.5.2.1	Rainfall	53
2.5.2.2	Temperature	54
2.5.2.3	Relative humidity	54
2.5.2.4	Wind speed	54
2.5.2.5	Cloud cover	54
2.5.2.6	Evaporation	55

Para No.	Particulars	Page No.
	Chapter – 3	55
	Interstate Aspects	
3.0	General	55
3.1	States traversed by the rivers	55
3.1.1	Bedti river	56
3.1.2	Dharma & Varada rivers (The tributaries of Tungabhadra river)	56
3.2	Various legal aspects on the link project	56
3.2.1	Sharing of waters	56
3.2.2	Submergence, PAPs, R&R etc.	57
3.2.3	Effect on project and of the project on the interstate adjudication, if any	
3.3	Effect on project and of the project on the existing and sanctioned projects	58
3.4	Interstate agreement/Legal instruments/Tribunal awards	58
3.5 (a)	Impact of water diversion on interstate water sharing agreement	58
3.5 (b)	Impact of water diversion on peninsular component	59
	Chapter – 4	61
	Surveys and Investigations	
4.0	General	65
4.1	Topographical surveys	65
4.1.1	Rivers	65
4.1.2	Reservoirs	66
4.1.3	Head works	67
4.1.4	Plant and colony layout	67
4.1.5	Canal and water conductor system and canal structures	
4.1.6	Power house, switch yard, surge shaft, tail race etc.	
4.1.7	Command area	69
4.2	Other surveys	71
4.2.1	Archaeological survey in the canal area	71
4.2.2	Mineral survey in the canal area	72
4.2.3	Right of way surveys for the reservoir	72

Para No.	Particulars	Page No.
4.2.4	Communication surveys	74
4.2.5	Drainage surveys	74
4.2.6	Soil surveys	78
4.2.7	Cadastral surveys	78
4.3	Geology, Geo technical features and seismicity	78
4.3.1	Geological and geotechnical investigations	78
4.3.2	Geophysical Investigations	78
4.3.3	Seismic investigations	78
4.4	Construction material survey	78
4.4.1	Rock and aggregates	79
4.4.2	Sand	79
4.4.3	Bricks and tiles	79
4.4.4	Pozzolana	80
4.4.5	Cement	80
4.4.6	Steel	80
4.4.7	Scarce material	81
4.4.8	Any other material	81
4.5	Hydrological and meteorological investigation	81
	Chapter – 5 Hydrology and Water Assessment	82
5.0	General	82
5.1	General climate and hydrology	82
5.2	General information about region	82
5.3	Specific information	82
5.3.1	Drainage basin	82
5.3.2	Command area	83
5.3.3	Floods and drainage	83
5.3.4	River geometry	
5.3.5	Groundwater recharge	84
5.3.6	Reservoir area	84
5.3.7	Catchment area upto diversion sites	85
5.3.8	Other water usage	87
5.3.9	Navigation	87
5.4	Data availability	91

Para No.	Particulars	Page No.
5.4.1	Rainfall and snowfall	91
5.4.2	Pan evaporation	94
5.4.3	Climatological parameters	96
5.4.4	River gauge and discharge	97
5.4.5	Sediment (Suspended and bed load) inflow	97
5.4.6	Water quality	100
5.5	Water availability studies	101
5.5.1	Methodology	101
5.5.2	Hydrological and water balance studies of the Bedti basin	101
5.5.2.1	Hydrological data requirement	102
5.5.2.2	Time unit for simulation studies	103
5.6	Compilation and processing of basic hydrological data	103
5.6.1	Hydrological Investigation	104
5.6.2	Data from other sources	104
5.6.3	Processing of data	104
5.6.4	Quality of data	105
5.6.5	Filling of short data gaps	108
5.6.6	Adjustment of records	108
5.6.7	Consistency of data	108
5.6.8	Availability of rainfall data	109
5.6.9	Availability of G&D data	109
5.6.10	Upstream utilisation	109
5.6.11	External consistency	109
5.7	Computation of yields at Pattanadahalla, Shalamalahalla and Suremane diversion sites	110
5.7.1	Development of rainfall-runoff equation at Suremane G&D site	110
5.7.2	Non-monsoon yield	110
5.7.3	Generation of yield series at Pattanadahalla, Shalamalahalla, Suremane diversion sites and for entire Bedti basin	110
5.8	Surface water requirement	115
5.8.1	Domestic water requirement	115

Para No.	Particulars	Page No.
5.8.2	Irrigation needs	116
5.8.3	Industrial needs	116
5.8.4	Hydropower needs	117
5.8.5	Environmental needs	117
5.8.6	Regeneration from irrigation	118
5.9	Water balance	119
5.9.1	Water balance upto Pattanadahalla, Shalamalahalla and Suremane diversion sites and in whole Bedti basin	120
5.9.1.1	Surface water availability	120
5.9.1.2	Surface water requirement for	122
5.9.1.3	Regeneration from	126
5.9.1.4	Surface water balance at	126
5.9.2	Water balance of Tungabhadra sub-basin at Tungabhadra dam site	127
5.10	Quantum of diversion	127
5.11	Effect of project on hydrologic regime	128
5.11.1	Effect on low flows	128
5.11.2	Effect on peak flood	128
5.11.3	Effect on total run-off	128
5.11.4	Effect on sediment flow	129
5.11.5	Effect on water demand	129
	Chapter – 6	129
	Design Aspects	
6.0	General	131
6.1	Geology, seismicity and foundation	133
6.1.1	Geology	133
6.1.2	Seismicity	133
6.1.3	Foundation treatment	134
6.2	Pattanadahalla weir	134
6.2.1	Design flood at Pattanadahalla weir	134
6.2.2	Hydraulic design of the weir	
6.3	Shalamalahalla weir	136
6.3.1	Design flood at Shalamalahalla weir	137
6.3.2	Hydraulic design of the weir	137

Para No.	Particulars	Page No.
6.4	Suremane barrage	138
6.4.1	Design flood at Suremane barrage	138
6.4.2	Hydraulic design of the barrage	138
6.5	Design of conveyance system	138
6.5.1	Link/canal alignment	139
6.5.2	Canal capacity	139
6.5.3	Design of canal	140
6.5.4	Tunnels	140
6.5.5	Lifting arrangements	141
6.5.6	Description of soil profile along the link alignment	141
6.5.7	Evaluation of design parameters	141
6.5.8	Transmission losses	142
6.6	Canal structures	143
6.6.1	Cross drainage/cross masonry works / regulators	144
6.6.2	Layout and foundation	145
6.6.3	Cross drainage works	146
6.6.4	Bridges	149
6.7	Integration of link canal with the existing Tungabhadra reservoir & TBLBC	154
6.8	Canal automation and branch canals	154
6.9	Instrumentation	154
6.10	Other studies	155
	Chapter – 7	155
	Reservoirs	
7.0	General	156
7.1	Pattanadahalla weir	156
7.1.1	Fixation of storage and weir levels	157
7.1.2	Water quality	157
7.1.3	Sedimentation	157
7.1.4	Life of weir	158
7.1.5	Area of submergence	158
7.1.6	Flood absorption	
7.2	Shalamalahalla weir	159
7.2.1	Fixation of weir levels	160

Para No.	Particulars	Page No.
7.2.2	Water quality	161
7.2.3	Sedimentation	161
7.2.4	Life of weir	164
7.2.5	Area of submergence	164
7.2.6	Flood absorption	164
7.3	Suremane barrage	164
7.3.1	Fixation of storage and barrage levels	164
7.3.2	Water quality	165
7.3.3	Sedimentation	165
7.3.4	Life of barrage	165
7.3.5	Area of submergence	165
7.3.6	Flood absorption / barrage operation policy	166
7.4	Land acquisition-property submerged-rehabilitation	166
7.5	Effect of the link project on the life of Tungabhadra reservoir	166
7.6	Capacities and sufficiency of the balancing reservoirs	166
	Chapter – 8 Irrigation planning and Command Area Development	167
8.0	General	167
8.1	Existing/proposed irrigation facilities in the target command area	167
8.1.1	Existing irrigation facilities	167
8.1.2	Proposed irrigation facilities in the target command area	167
8.2	Existing cropping pattern	168
8.2.1	Existing area irrigated under each crop and yield per ha	168
8.2.2	Net increase in irrigation facilities due to present project	168
8.3	Soil surveys	
8.3.1	Soil capability classification	170
8.3.2	Soil and Land irrigability classification	171
8.4	Agro-climatic conditions	171
8.4.1	Rainfall	172
8.4.2	Climatological parameters	173
8.4.3	Evaporation	173

Para No.	Particulars	Page No.
8.5	Proposed cropping pattern	174
8.5.1	Cropping pattern adopted under the link project	174
8.5.2	Proposed irrigation facilities	174
8.5.3	Scope for double & multiple cropping pattern and change in cropping pattern	176
8.6	Crop water requirement for irrigation	177
8.6.1	Monthly water requirement for irrigation	177
8.7	Water planning	178
8.7.1	Surface water	179
8.7.1.1	Water availability	179
8.7.1.2	Irrigation demand to be met under the link project	179
8.7.1.3	Domestic & industrial water supply	180
8.7.1.4	Transmission losses	181
8.7.1.5	Evaporation losses	181
8.7.2	Groundwater	182
8.7.2.1	Groundwater potential	183
8.7.2.2	Conjunctive use/groundwater support	183
8.8	Command area drainage	183
8.9	Water course / field channels	184
8.10	Water management	184
8.10.1	Review and evaluation of existing system of operation and distribution in the command and/or in some adjoining projects, if any	184
8.10.2	Proposals for Participatory Irrigation Management (PIM) including formation of Water Users Association (WUA)	184
8.10.3	Scope of introduction of modern technology like sprinklers, drip irrigation etc.	184
8.11	Command area	184
8.11.1	Location	185
8.11.2	Classification of land	186
8.11.3	Irrigation	186
8.11.4	Socio-economic aspects	186
8.11.5	Infrastructure facilities	186

Para No.	Particulars	Page No.
8.11.6	Identification of problems in command area	187
8.11.7	Proposed cropping pattern with justification	187
8.11.8	Land development work proposals	187
8.11.9	Benefits	187
	Chapter – 9	188
	Power	
9.0	General	189
9.1	Status of power development in Karnataka	189
9.1.1	Available generating capacity (MW) in Karnataka	190
9.1.2	Available generating capacity in the state (from different sources category wise)	191
9.1.3	Present status of utilisation of power	192
9.1.4	Capacity addition	192
9.2	Anticipated requirement of energy (MU) and peak load(MW)	192
9.3	Future plans of power development in the state	
9.4	Demand and supply of electricity	194
9.5	Power requirement for the link canal	194
9.6	Impact of link project on power scenario of the state	194
	Chapter – 10	198
	Environmental Impact Assessment and Environment Management Plan	
10.0	General	199
10.1	Objective of the study	200
10.2	The project proposal	202
10.2.1	The project background	202
10.2.2	The project justification	204
10.2.3	The projectdescription	205
10.3	The study area	206
10.4	Legal status of the project	
10.5	Baseline environmental data	208
10.5.1	Air environment	208
10.5.1.1	Ambient air quality	209

Para No.	Particulars	Page No.
10.5.2	Noise environment	210
10.5.3	Meteorology	211
10.5.4	Water quality	212
10.5.4.1	Surface water quality monitoring	213
10.5.4.2	Groundwater quality monitoring	214
10.5.5	Land environment	215
10.5.5.1	Land use	216
10.5.5.2	Mineral deposits	216
10.5.5.3	Historical/Archaeological monuments	218
10.5.5.4	Geology	218
10.5.5.5	Soils in the project command area	219
10.5.6	Terrestrial ecology	219
10.5.6.1	Delineation of flora in study area	222
10.5.6.2	Status of fauna	225
10.5.6.3	Status of fish fauna	225
10.5.7	Public health	226
10.5.7.1	Medical and health facilities in the project command area	226
10.5.7.2	Drinking water supply	226
10.5.7.3	Sanitation	227
10.5.7.4	Water borne and communicable diseases	227
10.5.7.5	Nutrition	227
10.6	Environmental Impact Assessment	227
10.6.1	Impact on air environment	228
10.6.1.1	Impact on air quality	228
10.6.2	Impact on noise environment	228
10.6.3	Impacts on water resources and quality	229
10.6.4	Impact on land environment	230
10.6.5	Impact on biological environment	230
10.6.5.1	Terrestrial environment	230
10.6.5.1.1	Impact on forest cover and protected area	231
10.6.5.2	Impact on aquatic ecology	231
10.6.6	Impacts on socio-economic environment	231
10.6.7	Impacts on micro climate	232

Para No.	Particulars	Page No.
10.6.8	Beneficial impact	233
10.6.8.1	Impact matrix	236
10.7	Environmental Management Plan	240
10.7.1	Controlling air quality at construction sites	240
10.7.1.1	Air pollution control	240
10.7.1.2	Noise control	241
10.7.2	Water pollution management	241
10.7.2.1	Surface water quality	243
10.7.2.2	Groundwater quality	243
10.7.3	Land management plan	243
10.7.3.1	Disposal of muck/excavated material	245
10.7.3.2	Restoration plan for quarry sites	245
10.7.3.3	Silt transfer	245
10.7.3.4	Command area management	246
10.7.3.5	Public health management	247
10.7.3.6	Management of flora and fauna	247
10.7.3.7	Earthquake management	248
10.7.3.8	Protection of sensitive and archaeological monument sites	248
10.7.4	Environment Monitoring Programme	248
10.7.5	Cost of Environmental Management Plan	249
	Chapter – 11 Socio-Economic Studies and Resettlement & Rehabilitation Plan	250
11.0	General	250
11.1	Socio-economic profile	250
11.1.1	Demography	251
11.1.2	Livestock	251
11.1.3	Agriculture	252
11.1.4	Literacy	252
11.1.5	Public health facilities	252
11.1.6	Educational facilities	
11.1.7	Land use pattern	254
11.1.8	Source of water for drinking, domestic and other	254

Para No.	Particulars	Page No.
	purpose in the project area	
11.1.9	Power supply	255
11.1.10	Transport facility	256
11.1.11	Banking and credit society facilities	257
11.1.12	Agricultural implements	257
11.1.13	Marketing facilities	258
11.1.14	Income sources	258
11.2	Socio-economic survey - Sample design and methodology	259
11.2.1	Questionnaire	261
11.3	Impact of Bedti – Varada link project	262
11.3.1	Short term impact of the link project	262
11.3.2	Long term impact of link project	262
11.3.3	Social impact assessment	263
11.3.3.1	Submergence area	263
11.3.3.2	Project affected villages	264
11.4	Resettlement and rehabilitation and its cost	264
11.4.1	Local area development plan	265
11.4.2	Monitoring and Evaluation	265
	Chapter – 12 Construction Program, Manpower Deployment and Plant Planning	266
12.0	General	266
12.1	Objective of the project	267
12.2	Main project components	267
12.3	Basis for the study	268
12.3.1	General	269
12.3.2	Construction material sources	269
12.3.3	Basic considerations	
12.3.3.1	Scheduled working hours	270
12.3.3.2	Construction program	270
12.4	Construction methodology and equipment planning	271
12.4.1	River diversion works	272
12.4.2	Weir/barrage components	273

Para No.	Particulars	Page No.
12.4.2.1	Pattanadahalla weir	273
12.4.2.2	Shalamalahalla weir	274
12.4.2.3	Suremane barrage	275
12.4.2.4	Major construction plant and equipment for weirs/barrage	275
12.4.3	Pumping components	276
12.4.3.1	Shalamalahalla weir to Varada river (Link –I)	277
12.4.3.2	Suremane barrage to Dharma river (Link-II) Stage-I & II	277
12.4.4	Tunnels	278
12.4.4.1	Pattanadahalla weir to Shalamalahalla	280
12.4.4.2	Shalamalahalla weir to Varada river (Link-I)	281
12.4.4.3	Tunnel from Suremane barrage to Dharma River(Link-II)	282
12.5	Deployment schedule	283
12.6	Total requirement of major construction equipment	283
12.7	Manpower planning	283
12.7.1	Organisation set-up	285
12.8	General purpose equipment and inspection Vehicles	287
12.9	Programme of year-wise expenditure	287
	Chapter – 13	292
	Cost Estimates	
13.0	General	296
13.1	Classification of units	300
13.2	Estimate for Link-I	301
13.2.1	Unit I: Head works	301
13.2.2	Unit II: Conveyance system(Canals,raising mains, tunnels)	301
13.2.3	Unit III: Lifting arrangements	302
13.2.4	Onfarm development	302
13.2.5	Estimated cost of Link-I	
13.3	Estimate for Link-II	304
13.3.1	Unit I: Head works	306
13.3.2	Unit II: Conveyance system (Canals,raisingmains,	307

Para No.	Particulars	Page No.
	tunnels)	
13.3.3	Unit III: Lifting arrangements	307
13.3.4	Onfarm development	312
13.3.5	Estimated cost of Link-II	317
	Chapter – 14 Revenues, Benefit Cost Ratio and IRR	
14.1	Yearly development programme from the date of starting construction of the link project	319
14.2	Source of revenue	319
14.3	Direct benefits	
14.3.1	Irrigation	319
14.3.2	Water charges (Irrigation service fee)	324
14.3.3	Domestic and industrial water supply	
14.3.4	Pisciculture	
14.3.5	Animal husbandry	
14.3.6	Other benefits	329
14.4	Indirect benefits	
14.5	Concession in water rates	
14.6	Administrative charges for water supply and revenue collection	
14.7	Redress of scarcity	
14.8	Commencement of realisation of the revenue	
14.9	Total Income from various sources	
14.10	Manpower for collection of revenue	
14.11	Annual costs	331
14.12	Benefit cost ratio (BCR)	
14.13	Internal rate of return(IRR)	331
14.14	Benefit cost ratio for flood control component	331
14.15	Role of the link project in the overall development of the region	
	Chapter – 15 Other Aspects	331
15.0	General	331

Para No.	Particulars	Page No.
15.1	Scope of the link project	332
15.2	Study of the link project	332
15.3	Dams vs. weirs/barrage	332
15.4	Requirements of EAC of MOEF & CC	332
15.5	Tunnelling method	333
15.6	Modernisation of Tungabhadra project	334
15.7	Change in scope of project	
15.8	Solar power potential	335
15.9	Memorandum of Understanding amongst Centre and concerned States	335
15.10	Financial resources	335
15.11	Future utilization of facilities created (Buildings)	336
15.12	Public co-operation and participation	336

Contents
Volume – II
Annexures of Report

Annexure No.	Particulars	Page No.
2.1	Normal monthly rainfall observed at different IMD observatories in Tungabhadra sub-basin	1
2.2	Monthly normal maximum and minimum temperature at different IMD Observatories in Tungabhadra sub-basin	2
2.3	Monthly normal relative humidity at different IMD observatories in Tungabhadra sub-basin	3
2.4	Monthly normal wind speed at different IMD observatories in Tungabhadra sub-basin	4
2.5	Monthly normal cloud cover at different IMD observatories in Tungabhadra sub-basin	5
2.6	Normal monthly potential evapotranspiration at different IMD observatories in Tungabhadra sub-basin	6
4.1	Salient features of Dharma Project	7
4.2	Salient features of existing Tungabhadra project	9
4.3	Elevation - Area - Capacity values of Tungabhadra reservoir (As per capacity survey – 2008)	12
4.4.1	Statement of bearings and distances of conveyance system under Link-I	15
4.4.2	Statement of bearings and distances of conveyance system under Link-II	16
5.1.1	Elevation – Area – Capacity values at Pattanadahalla weir site	19
5.1.2	Elevation – Area – Capacity values at Shalamalahalla weir site	20
5.1.3	Elevation – Area – Capacity values at Suremane barrage site	21
5.2	List, locations and corresponding normal annual rainfall of rain gauge stations in Bedti basin (Period of consideration 1970-71 to 2016-17)	23

Annexure No.	Particulars	Page No.
5.3	Monthly normal daily maximum and minimum temperature, relative humidity, wind speed, cloud cover and rainfall data at Honavar IMD observatory	24
5.4.1	Weighted average monsoon rainfall upto Suremane G&D site in Bedti basin (Catchment area = 2178 km ²)	25
5.4.2	Weighted average monsoon rainfall upto Pattanadahalla diversion site (Catchment area = 52.80 km ²)	27
5.4.3	Weighted average monsoon rainfall upto Shalamalahalla diversion site (Catchment area = 169.42 km ²)	29
5.4.4	Weighted average monsoon rainfall upto Suremane diversion site (Catchment area = 2078 km ²)	31
5.4.5	Weighted average monsoon rainfall of Bedti basin (Catchment area = 3902 km ²)	35
5.5	Monthly observed discharge data of Suremane G&D site for the period from 1970-71 to 1994-95	41
5.6	Computation of gross monsoon yields at Suremane G&D site for the period from 1970-71 to 1994-95	43
5.7.1	Development of rainfall-runoff relationship at Suremane G&D site by regression analysis for monsoon period assuming linear equation in the form $x_1 = a * x_2 + b$	44
5.7.2	Development of rainfall-runoff relationship at Suremane G&D site by regression analysis for monsoon period assuming non-linear equation in the form $x_1 = a * x_2 ^b$	46
5.8.1	Computation of average percentage of non-monsoon observed yield to the gross monsoon yield in the catchment upto Pattanadahalla gauge and discharge site	48
5.8.2	Computation of average percentage of non-monsoon observed yield to the gross monsoon yield in the catchment upto Sonda gauge and discharge site	49
5.8.3	Computation of average percentage of non-monsoon observed yield to the gross monsoon yield at Suremane G&D site	50
5.9.1	Computation of yield series using linear equation $X_1 = 1.21514 X_2 - 887.5742$ developed at Suremane G&D	51

Annexure No.	Particulars	Page No.
	site for catchment upto Pattanadahalla diversion site for the period from 1970-71 to 2016-17	
5.9.2	Computation of yield series using linear equation $X_1 = 1.21514 X_2 - 887.5742$ developed at Suremane G&D site for catchment up to Shalamalahalla diversion site for the period from 1970-71 to 2016-17	53
5.9.3	Computation of gross annual yield series of Bedti basin for the catchment area upto Suremane barrage site for the period from 1970-71 to 2016-17 using linear equation $X_1 = 1.21514 X_2 - 887.5742$ developed at Suremane G&D site	55
5.9.4	Computation of gross annual yield series of Bedti basin for the period from 1970-71 to 2016-17 using linear equation $X_1 = 1.21514 X_2 - 887.5742$ developed at Suremane G&D site	57
5.10.1	Projection of Human population to 2050 AD in the catchment area upto Pattanadahalla diversion site	59
5.10.2	Projection of Human population to 2050 AD in the catchment area upto Shalamalahalla diversion site	60
5.10.3	Projection of Human population to 2050 AD in the catchment area upto Suremane diversion site	61
5.10.4	Projection of Human population to 2050 AD for the entire Bedti basin	62
5.11.1	Livestock in the catchment upto Pattanadahalla diversion site and its projection to 2050 AD	63
5.11.2	Livestock in the catchment upto Shalamalahalla diversion site and its projection to 2050 AD	64
5.11.3	Livestock in the catchment upto Suremane diversion site and its projection to 2050 AD	65
5.11.4	Livestock in Bedti basin and its projection to 2050 AD	66
5.12.1.1	Annual irrigation and utilisation from existing major, medium and minor projects in the catchment upto Pattanadahalla diversion site	67
5.12.1.2	Annual irrigation and utilisation from proposed major,	68

Annexure No.	Particulars	Page No.
	medium and minor projects in the catchment upto Pattanadahalla diversion site	
5.12.2.1	Annual irrigation and utilisation from existing major, medium and minor projects in the catchment upto Shalamalahalla diversion site	69
5.12.2.2	Annual irrigation and utilisation from future major, medium and minor projects in the catchment upto Shalamalahalla diversion site	70
5.12.3.1	Annual irrigation and utilisation from existing projects in Bedti basin upto Suremane diversion site	71
5.12.3.2	Annual irrigation and utilisation from ongoing projects in Bedti basin upto Suremane diversion site	72
5.12.3.3	Annual irrigation and utilisation from proposed projects in Bedti basin upto Suremane diversion site	73
5.12.4.1	Annual irrigation and utilisation from existing projects in Bedti basin	74
5.12.4.2	Annual irrigation and utilisation from ongoing projects in Bedti basin	75
5.12.4.3	Annual irrigation and utilisation from proposed projects in Bedti basin	76
5.13.1	Monthly normal rainfall and potential evapotranspiration at Honavar IMD observatory	77
5.13.2	Computation of net and gross irrigation water requirement of different crops (Penman's Method)	78
5.13.2.1	Computation of weighted average delta for proposed medium projects in Bedti basin	88
5.13.2.2	Computation of weighted average delta for proposed minor projects in Bedti basin	89
5.13.2.3	Computation of weighted average delta for additional area proposed for irrigation in Bedti basin	90
5.14	Actual withdrawals through Tungabhadra Left Bank Canals (TLBC)	91
5.15.1	Net monsoon yield at Pattanadahalla diversion site	92
5.15.2	Net monsoon yield at Shalamalahalla diversion site	94

Annexure No.	Particulars	Page No.
5.15.3	Net monsoon yield at Suremane diversion site	96
5.16	Annual abstract of daily simulation carried out at Pattanadahalla site	98
5.16.1	Monthly inflow series considered for simulation at Pattanadahalla weir	100
5.16.2	Monthly abstract of daily simulation carried out at Pattanadahalla (Diversion)	102
5.16.3	Monthly abstract of daily simulation carried out at Pattanadahalla (Spills)	104
5.17	Annual abstract of daily simulation carried out at Shalamalahalla site	106
5.17.1	Monthly inflow series of Shalamalahalla (individual) at weir site	108
5.17.2	Monthly abstract of daily simulation carried out at Shalamalahalla (Combined diversion)	110
5.17.3	Monthly abstract of daily simulation carried out at Shalamalahalla (Spills)	112
5.18	Annual abstract of daily simulation carried out at Suremane site	114
5.18.1	Monthly inflow series considered for simulation at Suremane weir	116
5.18.2	Monthly abstract of daily simulation carried out at Suremane (Diversion)	118
5.18.3	Monthly abstract of daily simulation carried out at Suremane (Spills)	120
6.1.1	Design of weir on Pattanadahalla stream	122
6.1.2	Design of Tunnel from Pattanadahalla weir to Shalamalahalla	131
6.2.1	Design of weir on Shalamalahalla stream	135
6.2.2	Design of Vertical turbine pumps for Shalamalahalla weir	144
6.2.3	Design of Tunnel from Shalamalahalla to Varada at RD-10.15 km	149
6.3.1	Hydraulic design of Barrage at Suremane on Bedti river	153

Annexure No.	Particulars	Page No.
6.3.2	Hydraulic design of River sluice at Barrage on Bedti River for Other river bays	163
6.3.3	Design of Abutment at Barrage on Bedti river	169
6.3.4	Design of pier at barrage on Bedti River	172
6.3.5	Design of T shaped cantilever Wing wall U/S of barrage on Bedti river	174
6.3.6	Design of Radial Gate on River sluices at Barrage on Bedti river	176
6.3.7	Design of Road slab on Barrage at Bedti river	178
6.3.8	Design of Vertical turbine pumps at off-take of Suremane barrage stage-I	181
6.3.9	Design of Vertical turbine pumps on Suremane stage II (RD 10.90 km)	186
6.3.10	Design of Tunnel at 22.20 km of Suremane to Dharma reach (link-II)	191
6.4	Head loss statement	194
7.1	Salient features of Weirs and Barrage of Bedti - Varada link project	196
7.2	Water levels and storages in Tungabhadra reservoir	197
8.1	Distributary wise discharge and ayacut under TLBC	198
8.2	Monthly Normal daily maximum and minimum temperature, Relative Humidity, Wind Speed, Cloud cover and Rainfall data at Raichur IMD Observatory	201
8.3.1	Monthly Normal rainfall and potential evapotranspiration values at Raichur IMD Observatory	202
8.3.2	Computation of net and gross irrigation water requirement of different crops for Raichur Station (Penman Montieth Method)	203
8.3.3	Computation of weighted average delta for target command area under TLBC	207
8.4.1	Crop wise monthly water requirement in the target command area (Link-I)	208
8.4.2	Crop wise monthly water requirement in the target command area (Link-II)	209

Annexure No.	Particulars	Page No.
9.1	Computation of power requirement at various stages of lift from Shalamalahalla reservoir to stream leading to Varada river (Link-I)	210
9.2.1	Computation of power requirement at various stages of lift from Suremane barrage Stage-I (Link-II)	213
9.2.2	Computation of power requirement at various stages of lift from Suremane barrage Stage-II (Link-II)	216
10.1	Minutes of the 93 rd Meeting of the Expert Appraisal Committee (EAC) for River Valley and Hydroelectric Projects held on 2 nd May, 2016 at Indus Meeting Hall, Ground Floor, Jal Wing, Indira Paryavaran Bhawan, Jor Bagh Road, New Delhi – 110003.	219
12.1	Abstract of quantities of earth work excavation and concreting	223
12.2.1	Construction Schedule (Link I)	224
12.2.2	Construction Schedule (Link II)	
12.3	Special T&P	225
12.4	Organisation Chart	226
12.5	Annual Financial Outlay	
13.1	Abstract of cost	227
13.1.1	Unit-I : Head works (Link-I & Link-II) Abstract of Cost	228
13.1.2	Unit - II : Conveyance system (Link-I & Link-II)	229
13.1.3	Unit - III : Lifting arrangements (Link-I & Link-II)	230
13.2.1	Unit-I : Head works (Link – I)	231
13.2.1.1	Link – I Head works (B-Land)	232
13.2.1.2	C-Works	233
13.2.1.2.1	C. Works (Head works of Link-I) Abstract of cost of Pattanadahalla weir (Link-I)	234
13.2.1.2.2	C. Works (Head works of Link-I) Abstract of cost of Shalamalahalla weir	242
13.2.1.3	Head works (Link-I) M - Plantation	250
13.2.1.4	Head works (Link-I) R-Communications	251
13.2.1.5	Head works (Link-I) X-Environment and Ecology	252
13.2.2	Link-I Unit - II : Conveyance system	253

Annexure No.	Particulars	Page No.
13.2.2.1	Link – I Conveyance System (B-Land)	254
13.2.2.2	Link – I Conveyance System (C-Works)	255
13.2.2.2.1	Link – I Conveyance System (C-Works) Abstract of cost for canal in the alignment between Pattanadahalla and Shalamalahalla	256
13.2.2.2.2	Link – I Conveyance System (C-Works) Abstract of cost for canal in the alignment from Shalamalahalla to tributary of Varada river	259
13.2.2.2.3	Link – I Conveyance System (C-Works) Abstract cost of Tunnel at RD 0.1 km to 6.6 km in the link alignment from Pattanadahalla to Shalamalahalla (including exit and entry portal and adit)	262
13.2.2.2.4	Link – I Conveyance System (C-Works) Abstract cost of Tunnel at RD 10.15 km to 16.85 km in the link alignment from Shalamalahalla to stream leading to Varada river (including delivery cistern, adit and exit portal)	268
13.2.2.2.5	Link – I Conveyance System (C-Works) Abstract of cost of Pipeline (Raising main) from Shalamalahalla to Varada river	275
13.2.2.3	Link – I Conveyance System M-Plantation	285
13.2.2.4	Link – I Conveyance System R-Communications	287
13.2.2.5	Link – I Conveyance System W Drainage & X - Environment & ecology	288
13.2.3	Unit - III: Lifting arrangements	289
13.2.3.1	Cost estimate of J & S – Pump house civil & electrical works for the lifting arrangements from Shalamalahalla diversion site	290
13.3.1	Unit - I: Headworks (Link-II)	291
13.3.1.1	Link-II: Headworks (B: Land)	292
13.3.1.2	C. Works - Abstract of cost of Suremane barrage (Link-II)	293
13.3.1.3	Head works (Link-II) M Plantation	305
13.3.1.4	Head works (Link-II) R- Communications	306

Annexure No.	Particulars	Page No.
13.3.1.5	Head works (Link-II) X Environment and ecology	307
13.3.2	Unit - II: Conveyance system	308
13.3.2.1	Link-II: Conveyance system (B: Land) Abstract of cost of Land acquisition	309
13.3.2.2	Link-II: Conveyance system Abstract of cost of C- works	310
13.3.2.2.1	Link-II: Conveyance system (C: Works) Abstract of cost of Pipeline (Raising main) from Suremane to Dharma river	311
13.3.2.2.2	Link-II: Conveyance system (C: Works) A. Abstract of cost of Suremane tunnel	321
13.3.2.3	Link-II: Conveyance system M-Plantation	322
13.3.2.4	Link-II: Conveyance system R-Communications	323
13.3.2.5	Link-II: Conveyance system W Drainage and X - Environment & ecology	324
13.3.3	Link-II Unit - III: Lifting arrangements	325
13.3.3.1	Link-II Cost estimate of J & S – Pumphouse civil & electrical works for the lifting arrangements at Suremane diversion site	326
14.1	Abstract of benefits from the link project	
14.2.1	Gross value of produce for the area under link canal(Pre-irrigation&Post-irrigation)	327
14.2.2	Input cost of agriculture for the area under link canal (Pre-irrigation& Post-irrigation)	328
14.2.3	Net annual benefits from irrigation	329
14.3	Revenue from irrigation cess	330
14.4	Net benefits from domestic and industrial water supply	
14.5	Benefits from Pisciculture	331
14.6	Calculation of Benefit-Cost Ratio(Link-I + Link-II combined)	
14.6.1	Calculation of Benefit-Cost Ratio(Link-I)	332
14.6.2	Calculation of Benefit-Cost Ratio(Link-II)	333
14.7	Internal Rate of Return (IRR) - (Link-I + Link-II combined)	334
14.7.1	Internal Rate of Return (IRR) - Link-I	338

Annexure No.	Particulars	Page No.
14.7.2	Internal Rate of Return (IRR) - Link-II	342

Volume – III
Drawings

Sl. No.	Title	Plate No.
1	Vicinity map	1.1
2	Index Map of BEDTI-VARADA link Project	1.2
3	Basin map of Bedti	2.1
4	Basin map of Krishna	2.2
5	Sub-Basin map of Tungabhadra	2.3
6	Canal alignment of Bedti-Varada link (Link-1) from Pattanadahalla Weir to Shalamalahalla Weir & to Varada river	4.1(1/2)
7	Canal alignment of Bedti-Varada link from Suremane weir on Bedti River to Dharma river (Link-2)	4.1(2)
8	Contour plan of Pattanadahalla weir & water spread area	4.1.1(a)
9	Contour plan and Cross section along Pattanadahalla weir axis	4.1.1(b)
10	Contour plan and L-Section of link alignment from Pattanadahalla to Shalamalahalla RD-0.00 km to 2.0 km	4.1.1(C)(1/4)
11	Contour plan and L-Section of link alignment from Pattanadahalla to Shalamalahalla RD-2.00 km to 4.0 km	4.1.1(C)(2/4)
12	Contour plan and L-Section of link alignment from Pattanadahalla to Shalamalahalla RD-4.00 km to 6.0 km	4.1.1(C)(3/4)
13	Contour plan and L-Section of link alignment from Pattanadahalla to Shalamalahalla RD-6.00 km to 8.10 km	4.1.1(C)(4/4)
14	Contour plan of Shalamalahalla weir & water spread area	4.1.2(a)
15	Contour plan and Cross section along Shalamalahalla weir axis	4.1.2(b)

Sl. No.	Title	Plate No.
16	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-0.0 km to 2.0 km	4.1.2(C)(1/9)
17	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-2.0 km to 4.0 km	4.1.2(C)(2/9)
18	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-4.0 km to 6.0 km	4.1.2(C)(3/9)
19	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-6.0 km to 8.0 km	4.1.2(C)(4/9)
20	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-8.0 km to 10.0 km	4.1.2(C)(5/9)
21	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-10.0 km to 12.0 km	4.1.2(C)(6/9)
22	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-12.0 km to 14.0 km	4.1.2(C)(7/9)
23	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-14.0 km to 16.0 km	4.1.2(C)(8/9)
24	Contour plan and L-Section of link alignment from Shalamalahalla to Varada river from Rd-16.0 km to 18.58 km	4.1.2(C)(9/9)
25	Contour plan of Suremane weir & water spread area	4.1.3(a)
26	Contour plan and Cross section along Suremane weir axis	4.1.3(b)
27	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 0.0 km to 2.0 km	4.1.3(C)(1/14)

Sl. No.	Title	Plate No.
28	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 2.0 km to 4.0 km	4.1.3(C)(2/14)
29	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 4.0 km to 6.0 km	4.1.3(C)(3/14)
30	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 6.0 km to 8.0 km	4.1.3(C)(4/14)
31	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 8.0 km to 10.0 km	4.1.3(C)(5/14)
32	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 10.0 km to 12.0 km	4.1.3(C)(6/14)
33	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 12.0 km to 14.0 km	4.1.3(C)(7/14)
34	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 14.0 km to 16.0 km	4.1.3(C)(8/14)
35	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 16.0 km to 18.0 km	4.1.3(C)(9/14)
36	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma From 18.0 km to 20.0 km	4.1.3(C)(10/14)
37	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma From 20.0 km to 22.0 km	4.1.3(C)(11/14)
38	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma From 22.0 km to 24.01 km	4.1.3(C)(12/14)
39	Contour plan and L-Section of link alignment	4.1.3(C)(13/14)

Sl. No.	Title	Plate No.
	from Suremane weir on Bedti river to Dharma from 24.0 km to 26.01 km	
40	Contour plan and L-Section of link alignment from Suremane weir on Bedti river to Dharma from 26.0 km to 26.88 km	4.1.3(C)(14/14)
41	Cadastral map of Bedti-Varada Link alignment	4.1.4(1/3)
42	Cadastral map of Bedti-Varada Link alignment from Pattanadahalla, Shalamalahalla to Varada river	4.1.4(2/3)
43	Cadastral map of Bedti-Varada Link alignment from Suremane weir on Bedti river to Dharma river	4.1.4(3/3)
44	Map showing Location of Quarry	4.12
45	Isohyetal map of Bedti basin	5.1
46	Isohyetal map of Krishna basin	5.2
47	Isohyetal map of Tungabhadra sub-basin	5.3
48	Layout plan of proposed Pattanadahalla weir	6.1.1
49	Plan and Cross section of proposed Pattanadahalla weir	6.1.2
50	Layout plan of proposed Shalamalahalla weir	6.2.1
51	Plan and Cross section of proposed Shalamalahalla weir	6.2.2
52	Layout Plan of proposed Barrage at Suremane on Bedti River	6.3.1
53	Suremane Barrage Plan	6.3.2
54	Suremane Barrage under sluice and river sluice	6.3.3
55	Suremane barrage radial gate	6.3.4
56	Typical sections of link canal in embankment & partial filling and cutting	6.6
57	Typical section of Tunnel, portal Excavation support of Entry & Exit portal	6.7.1
58	Tunnel support system, concrete lining, and grouting details	6.7.2
59	Typical details of canal lining	6.8.1

Sl. No.	Title	Plate No.
60	Typical Drainage arrangement of lined canal	6.8.2
62	Command area maps	8.0
63	Communication Map	