ECONOMIC AND FINANCIAL ANALYSIS

A. Introduction

1. The Climate Adaptation in Vennar Subbasin in Cauvery Delta Project will (i) upgrade flood risk management and irrigation infrastructure, and (ii) establish improved water and flood risk management systems. The expected outcome is improved climate-resilient water management in the Vennar system. The project is aligned with two key government objectives. First, coastal districts are protected from cyclonic storms and flooding exacerbated by climate change.[1] Second, economic growth, including agricultural growth, in Tamil Nadu is accelerated, innovative, and inclusive.[2]

2. The project focus is on the lower Vennar system, and the project has seven subprojects: (i) Adappar channel, (ii) Harichandra channel, (iii) Vellaiyar channel, (iv) Pandavayar river, (v) Valavanar drain, (vi) Vedharanyam canal and coastal straight cuts, and (vii) 13 pumped irrigation schemes. Each subproject consists of a number of components such as regulators, head sluices, drainage sluices, drainage infalls, siphons, bed dams, grade walls, and bridges. In addition, there are earth works for re-sectioning channels, including flume-sections and roads. In the case of the pumped irrigation schemes, the components are electrical and mechanical equipment in the pump houses. All subprojects (except the pumped irrigation schemes) include necessary works on ancillary structures such as footbridges, ramps, and cremation grounds, and resettlement and environmental costs.

B. Macroeconomic Assessment

3. India has shown progress in both gross domestic product (GDP) growth and poverty reduction. Annual real GDP increased from $1,226 billion in 2008 to $1,840 billion in 2012. The proportion of the population below the poverty line declined from 45.3% in 1994 to 21.9% in 2012. The Indian agriculture sector accounted for 18.4% of India's GDP and employed 47% of the country's workforce in 2013. This sector made considerable progress since the 1990s with its large resources of land, water, and sunshine. India is presently the world's largest producer of pulses and the second-largest producer of rice and wheat. Agricultural growth is variable from year to year since it depends on the monsoon, among other factors, and in recent years has varied between 0.1% in 2008, 8.6% in 2010, and 4.6% in 2013. In Tamil Nadu, agriculture directly contributed 21% of state GDP in 2012 and, including fisheries and forestry, directly or indirectly provides employment for more than 60% of households.

C. Demand Analysis

4. The objective of the project is to maintain the agricultural status quo of the Vennar system through repairs to and reconstruction of irrigation structures and pumping stations. The project will also make the system more resilient to flooding and climate change by strengthening river embankments, widening channels, and constructing river-training works. A small number of new structures are proposed, especially at the tail end of the system. No new irrigation command areas will be created. The with-project scenario assumes that all beneficiaries would maintain their present sources of irrigation.

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[1] http://www.forests.tn.nic.in/graphics/TN_Vision_2023.pdf

[2] Government of Tamil Nadu. State Planning Commission. 2012. *Twelfth Five Year Plan (2012–2017).* Chennai. http://www.spc.tn.gov.in//12plan_english/vision.pdf

5. The without-project scenario assumes that irrigation command areas (*ayacuts*) would experience reduced productivity, depending on their access to fresh groundwater and location in the irrigation system. *Ayacuts* with conjunctive use of gravity or pumped surface water and groundwater would lose surface water supply and become dependent on groundwater only. However, in the absence of enough borewells, groundwater is only available to 28% of farmers (and 28% of the area), hence groundwater supply is not sufficient to irrigate the full area. In the without-project scenario, *ayacuts* with only surface water would lose their supply and become dependent on rainfall.

D. Rationale

6. The economic rationale for the project is that the economic benefits of sustained water supplies and flood control are unlikely to be supplied in the absence of government intervention. Private sector investment is discouraged since it is not possible to recover revenues from water charges at commercially viable rates. Moreover, the large scale of investment in irrigation and flood-control works required in the project area precludes private sector investment because it is beyond the financial and managerial capacity of most private sector firms. The project will contribute to national poverty alleviation policies since a high proportion of project benefits will accrue to poor rural households.

E. Project Alternatives

7. The objective of the proposed project is to provide water and flood control to the project area while minimizing adverse impacts on the existing system and the environment. A large number of studies and simulations were undertaken to select the infrastructure that would best achieve this objective. Two evaluation scenarios were developed to measure the economic benefits of the project: (i) with-project (i.e., rehabilitation of the schemes), and (ii) without-project (no rehabilitation and reduction in agricultural productivity).

F. Methodology and Data

1. General

8. **Key assumptions**. The economic analysis of the project was carried out by comparing with-project and without-project scenarios following Asian Development Bank (ADB) guidelines for the economic analysis of projects[3]). The economic analysis is based on the following assumptions:

- (i) the project life is 35 years;
- (ii) the salvage value at the end of the project life is assumed to be zero;
- (iii) benefit flows are expected to start in the year following investment, with a build-up to full benefits over 10 years thanks mainly to non-project agronomic interventions;
- (iv) economic costs and benefits are expressed in constant 2014 terms with an exchange rate of Rs.65=$1.00, and are valued using the world price numéraire;
- (v) taxes and duties, interest and price contingencies are excluded from the economic costs;
- (vi) economic costs and benefits for nontradable goods and services are derived by adjusting their values by the standard conversion factor (SCF) of 0.90 and removing taxes; and
- (vii) a shadow wage rate (SWR) factor of 0.90 was applied for unskilled farm labor.

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[3] ADB.1997.*Guidelines for the Economic Analysis of Project.* Manila.

9. All existing infrastructure are considered sunk costs, hence their costs are not included. A so-called Monte Carlo simulation framework was used to estimate the project benefits because the remaining life of the irrigation and drainage structures, and of the pumping schemes to be repaired or replaced, cannot be known with certainty. For structures that need to be repaired or replaced, it was assumed that productivity in the *ayacuts* that they serve would begin to decline after 5 to 10 (average 7.5) years in the without-project scenario. If the pumped irrigation schemes are not rehabilitated, it is assumed that pumping would cease after 3 to 7 (average 5) years. The risk modeling framework uses a triangular probability distribution of the years in which the structures and pumping schemes would fail in the without-project scenario. The probability distribution is specified by minimum, mean, and maximum values.

2. Project Benefits

10. Agricultural benefits are expected to result from maintaining agricultural productivity at present levels by (i) repairs or reconstruction of irrigation structures, and (ii) rehabilitation of pumping schemes by restoring water supplies to the original *ayacuts*. Avoided flood damages of crops in the lower end of drainage areas are used to justify investments for repair or reconstruction of drainage sluices, drainage infalls, siphons, and tail-end regulators. Weighted average annual avoided flood damages are used to justify improvements of river embankments or the widening of channels, and the construction of river-training works.

11. Separate productivity levels were specified on the basis of groundwater quality, location, and climate change scenario. First, a distinction is made between *ayacuts* with fresh groundwater and *ayacuts* with saline groundwater—the border between fresh and saline groundwater is taken as 250 parts per million (ppm) chloride. Second, the location of the *ayacut* is important as tail-end *ayacuts* (defined as those for which the bottoms of the rivers at the tail-end regulators lie at or below sea level) have a less-assured surface water supply and a lower productivity level than *ayacuts* located higher up in the system. Furthermore, tail-end *ayacuts* do not have access to fresh groundwater. Third, in order to assess the future impacts of climate change, productivity levels under moderate and severe climate change impacts have been defined for the tail-end *ayacuts*.

12. The present and future productivity levels of the command areas of all structures and lift irrigation schemes were identified as (i) conjunctive use of surface and groundwater; (ii) groundwater from borewells only; (iii) surface irrigation full supply; (iv) surface irrigation tail end; (v) surface irrigation tail end with moderate impact of climate change; and (vi) surface irrigation tail end with severe impact of climate change. The expected effect of the repairs to and reconstruction of structures, and the rehabilitation of pump irrigation scheme are to maintain the present productivity level until 2050.

13. For the without-project scenario, the productivity of command areas would decline depending on access to fresh groundwater and location in the irrigation system. *Ayacuts* with conjunctive use of gravity or pumped surface water and groundwater would lose their surface water supply and would then become dependent only on groundwater. The region has not enough borewells, hence groundwater is not available to all farmers and it is not possible to irrigate the full area using groundwater. In the without-project scenario, *ayacuts* with only surface water supply would become dependent on rainfall. However, the project area is located within a rain shadow because the Western Ghat mountains effectively cut off the southwest monsoon, so in effect only one monsoon occurs in this part of Tamil Nadu. Consequently, rainfall is so erratic and unreliable that cultivation of rainfed annual crops in practice does not occur. Data for future changes in productivity without the project was obtained through an expert

opinion approach, using local engineers and an agronomist.

14. For structures that need to be repaired or replaced, it was assumed that the decline in productivity would happen after 10 years in the without-project scenario. If the pumped irrigation schemes were not rehabilitated, it was assumed that pumping would stop after 5 years.

15. The benefits of the repairs to or renovation of drainage sluices, drainage infalls, and siphons consist of avoided crop losses due to poor drainage. It was assumed that poor drainage affects 10% of the drained command areas and that the losses would be 80% of the financial and economic production costs of paddy.

16. Flood protection benefits consist of avoided flood damages, which occur at irregular intervals and at different scales, depending on the severity, timing, and duration of the flood. Flood damage data were collected in the project area for the Thiruvarur and Nagapattinam districts, for the 10-year period 2004–2015, and for loss of life, loss of livestock, and damages to crops, irrigation infrastructure, houses, and roads. Historical damage values were converted to 2015 values using GDP deflators. The annual values do not include indirect damages or costs such as costs for temporary relief measures, loss of labor opportunities, health expenses, temporary relocation, cleaning up, and disruption of transport, trade, and education.

17. The frequency (return periods) of the floods causing the damage in the period 2004–2013 was obtained from hydrologic analysis and hydraulic modeling; in 2014, no flooding occurred, the return period of the 2015 flood was estimated by Tamil Nadu's Water Resources Department (WRD). Weighted average annual flood damage values were estimated using a probability-based approach and taking the project life into account. The flood protection provided by the project was designed to contain a one-in-25-years (1:25) flood. For floods with a lower return period, most losses can be avoided with the proposed project works, and for floods with a higher return period, the reduction of losses will only be partial. Flood damage reduction factors were estimated by the consultant team. By dividing the total cost of the damage by the areas of the two districts, the annual flood benefit per hectare for the with-project scenario was obtained. The average annual damage reduction of Rs2,363 per hectare (ha) per year ($36/ha/year) is insufficient to justify large investments in flood protection. With the project, but without climate change, there would be a reduction in the flooded area from 249 square kilometers (km^2) to 118 km^2. With the project, but with climate change, the reduction in the flooded area would be from 262 km^2 to 135 km^2, implying that in the case of climate change, 15% more area would be flooded during a 1:25 flood. In the case of a with-project medium climate change scenario, it was assumed that the flood protection benefits would be 10% less than in the without-climate-change scenario. In the case of a severe climate change scenario, these benefits were assumed to be 20% less.

18. The agricultural seasons and possible crops per season in the project area are (i) Kuruvai (May–August) with paddy, (ii) Thaladi (September/October–March) with paddy, (iii) Samba (July/August–January) with paddy, followed by (iv) Summer (February–July) with black gram/green gram/gingelly (sesame), using residual moisture from surface irrigation, or groundwater irrigation, depending on availability, and (v) annual with sugarcane (1 year). Paddy is only grown during the monsoon period since there is no supplementary water from other sources during the dry season, except where groundwater is available. However, groundwater in the project area is mostly saline, making irrigated cropping impossible in the monsoon period. Cropping patterns were prepared for all of the above-mentioned productivity levels (Tables 1 and 2). To each cropping pattern corresponds a total annual financial and economic crop net benefit. These benefits were calculated for the present situation (2015) and for 2025 (at constant FY2015 prices).

Table 1: Cropping patterns for 2015 (%)

Season/crop	CUSE	GRWT	SIFS	SITE	SIMC	SISC
Kuruvai						
Paddy	90	30				
Thaladi						
Paddy	90	30				
Samba						
Paddy			100	100	80	60
Summer						
Black/Green gram RF			20	10		
Black/Green gram IR	30	5				
Gingelly rice-followed			10	5		
Gingelly irrigated	10	5				
Biannual						
Sugarcane	10					
Total	**230**	**70**	**130**	**115**	**80**	**60**

CUSE = conjunctive use of surface and groundwater; GRWT = groundwater from borewells only (this cropping pattern is based on groundwater being available only to about 30% of the area); SIFS = surface irrigation full supply; SIMC = surface irrigation tail end with moderate impact of climate change; SISC = surface irrigation tail end with severe impact of climate change; SITE = surface irrigation tail end.

Table 2: Cropping patterns for 2025 (%)

Season/crop	CUSE	GRWT	SIFS	SITE	SIMC	SISC
Kuruvai						
Paddy	85	30				
Thaladi						
Paddy	85	30				
Samba						
Paddy			100	100	60	40
Summer						
Black/Green gram RF			20	10		
Black/Green gram IR	40	5				
Gingelly rice-followed			10	5		
Gingelly irrigated	15	5				
Biannual						
Sugarcane	5					
Total	**230**	**70**	**130**	**115**	**60**	**40**

CUSE = conjunctive use of surface and groundwater; GRWT = groundwater from borewells only (this cropping pattern is based on groundwater being available only to about 30% of the area); SIFS = surface irrigation full supply; SIMC = surface irrigation tail end with moderate impact of climate change; SISC = surface irrigation tail end with severe impact of climate change; SITE = surface irrigation tail end.

19. The project will generate benefits that were not quantified and included in the analysis. These include benefits accruing from the following project activities that are not captured directly through impacts on crop production: (i) improved planning system with comprehensive implementation plans; (ii) strengthened water users' associations to undertake operations and maintenance of at least minor facilities, support agriculture extension, and marketing; and (iii) improved irrigation and related service delivery mechanism with transparent and accountable governance through water users' associations. Non-quantified benefits will also be derived from strengthening policy, planning, and the institutional framework (including participatory irrigation management and integrated water resource management). The economic analysis also excluded impacts associated with livestock production (which may benefit from increased volumes of crop residues as fodder), minor fisheries, canal maintenance, improvement of roads and bridges on rural transport, and public health benefits from improved drainage and water management.

3. Project Costs

20. The costs of each subproject were estimated based on the basic design of proposed structures and rehabilitation works. Quantity and cost estimates were based on 2014 WRD unit rates, which include all direct and indirect costs, labor, equipment, materials, services, and overhead. Financial costs were converted to economic costs by applying the SCF. An annual maintenance budget of 2% of the investment costs was included in the cost–benefit analysis, and a major overhaul of the renovated and new structures was included after 20 years at one-third of the investment cost. For the pumping schemes, it was assumed that a mechanical overhaul, costing one-third of the investment costs, would be required after 15 and 30 years. The resettlement and environmental management and monitoring costs were included in the project costs.

21. The total project cost in economic terms is Rs7,679 million (Table 3). The cost is predominantly made up of the six river subprojects (Rs7,552 million) and, to a much lesser extent, the pumping schemes (Rs128 million). Earth works are the largest cost component (Rs4,651 million), followed by structures (new, repairs, reconstruction; Rs1,727 million). Additional costs are footbridges, ramps, crematorium sites, among other things. Resettlement costs (Rs680 million) and environmental costs (Rs46 million) complete the cost picture.

Table 3: Economic Project Costs
(Rs million)

Components	Structures	Earth works	Additional	Resettlement	Environment	Total
Adappar	476	979	16	103	8	1,581
Harichandra	503	1,663	86	261	8	2,521
Vellaiyar	425	974	155	219	8	1,780
Pandavanar	209	521	149	86	8	973
Vallavanar Drain	29	347	14	1	7	398
Vedharanyan Canal	85	167	29	9	8	298
Subtotal	1,727	4,651	448	680	46	7,552
Pumping Schemes						128
Total						**7,679**

Note: Numbers may not sum precisely because of rounding.

G. Results

22. The results of the economic analysis for the individual schemes are given in Table 4. The Adapar river flows in the saline and tail-end productivity zones, and the benefits are therefore limited because they are mostly related to drainage, resulting in a modest economic internal rate of return (EIRR) of 10.2%. The Harichandra river starts in the fresh groundwater zone, then flows in the saline and tail-end productivity zones, hence the benefits are favorable and the economic result is good (EIRR 17.1%). The Vellaiyar and Pandavanar rivers flow across the fresh groundwater and saline productivity zones, resulting in substantial benefits and in good returns (EIRRs of 20.2% and 19.2%). The Vellavanar Drain and the Vedharanyan Canal flow in the saline and tail-end productivity zones and have only limited direct benefits (EIRRs of 0.0% and 5.6%). These systems are economically, physically, and socially with the rest of the project area, hence for the consistency of the project, it is suggested to keep these water bodies within the project. The overall EIRR is well above the cut-off rate of 12%.

Table 4: Base-Case Economic Results for Subprojects and Overall Project (%)

Components	EIRR (%)
Adappar	10.2%
Harichandra	17.1%
Vellaiyar	20.2%
Pandavanar	19.2%
Vallavanar drain	…
Vedharanyan canal	5.6%
Pumping schemes	40.3%
Total Project	**18.3%**

… = not applicable, EIRR = economic internal rate of return.

23. Of the 13 pumping schemes, 12 have an EIRR above 12% in the base case. The pumping schemes are fully independent of each other; and the poorly performing Velankanni scheme (EIRR 9%) could be dropped from the project scope. In the "medium climate change" case, 10 schemes retain EIRRs above 12%, as the water sources for the other schemes would turn saline. However, it is most likely that any significant change in climate would not occur before the end of the economic life of these investments.

24. Table 5 presents the results of the sensitivity and Monte Carlo simulation analysis for (i) base case, (ii) medium climate change, (iii) severe climate change, (iv) 20% cost increase, (v) 20% benefit reduction, and (vi) a combination of 20% cost increase and 20% benefit reduction. The baseline EIRR is 18.3% and drops to 14.5% in the worst-case scenario, indicating that the project is economically viable under all assumptions.

Table 5: Results of Monte Carlo Analysis of Economic Returns at Project Level (%)

	Base Case	Medium Climate Change	Severe Climate Change	Cost Increase 20%	Benefit Reduction 20%	Cost Increase & Benefit Reduction 20%
Mean	**18.3%**	**17.3%**	**16.8%**	**16.3%**	**16.3%**	**14.5%**
Minimum	17.2%	15.0%	14.6%	15.3%	15.2%	13.6%
Maximum	19.8%	17.3%	17.0%	17.4%	17.5%	15.5%
Standard deviation	0.3%	0.3%	0.3%	0.3%	0.3%	0.3%
95% lower limit	**17.6%**	**16.6%**	**16.1%**	**15.7%**	**15.7%**	**14.0%**
95% upper limit	**19.0%**	**17.9%**	**17.4%**	**16.9%**	**16.9%**	**15.0%**
Probability EIRR>12%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

EIRR = economic internal rate of return.

H. Distribution and Poverty Analysis

25. A distribution analysis of the subproject costs and benefits was undertaken for the project to determine the distribution of the benefits over the various stakeholder categories: farmers, marginal farmers (with less than 1 ha of land), hired labor and/or landless, and government and/or society, and to calculate the poverty impact ratio. In this analysis, first, the present value of the incremental benefits (maintained agricultural production) and project costs for each subproject was calculated over a 35-year period at a discount rate of 12%, using financial prices. The financial benefits (gains) and costs (losses) expected to be generated by the subprojects were distributed across the stakeholders, showing the net benefits accruing to each of these categories. Second, the present value of the incremental benefits and project costs for each subproject were calculated over the same period with the same discount rate, using economic prices. The differences between the economic and financial present values are caused by the application of the SWR and the SCF. The SWR is applied to labor and the SCF is used for the removal of duties and taxes. For own and hired labor for the incremental

agricultural production, the present values of the SWRs were calculated using the labor requirements specified in the potential crop budgets. These values were assigned to the respective categories, using the distribution as found during the socioeconomic survey. The results of the analysis indicate that the bulk of the net benefits go to the farmers (58%) and marginal farmers (42%). The poverty impact ratio is 26%, indicating that one-quarter of the project benefits go to the poor (Table 6).

Table 6: Poverty Impact Analysis
(Rs million)

Beneficiaries	Farmers	M. Farmers	H. Lab/ Landless	Govt./Economy	Total
PV Economic - PV Financial	90	67	19	6,316	6,492
Financial Return	4,886	3,571	0	0	8,457
Net Benefits	4,976	3,638	19	6,316	14,949
Proportion of Poor (%) */1*	*51%*	*38%*	*11%*		
Net Benefits to Poor	2,538	1,382	2	0	3,922
Poverty Impact Ratio					**26%**

Govt. = government, H. Lab = hired labor, M = marginal, PV = present value.

I. Financial Sustainability of Project Investments

26. Beneficiaries presently do not pay for irrigation investment and operation and maintenance, nor for the power for pumping, and will not do so in future since it is the policy of the Government of Tamil Nadu to supply these services free of charge. The financial sustainability therefore depends fully on the timely availability of operation funds supplied by the government to WRD.

27. In the state budget for fiscal year 2016, an amount of Rs20 million was earmarked as local contribution to the project.[4]

[4] Chief Minister of Tamil Nadu (25 March 2015): Speech presenting the Budget 2015-16 to the Legislative Assembly.