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Cost Overrun Risks in Infrastructure Projects: Case of Hydroelectric Projects

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Abstract—*Hydroelectric projects in-spite of being a clean & renewable source providing inflation free and multipurpose benefits have been in recent past looked down by planners and policy makers in India for their poor track record with regard to their cost and time management . The paper through literature studies examines the problem, its magnitude, causes and the gaps for undertaking further research. There is limited availability of reliable and documented cost details over the complete project cycle from approval to completion stage. Most of the existing research is based on surveys and interviews of stakeholders and there is urgent need for further research for reliable and documented reporting of actual cost details of projects. A research methodology is evolved which after studying unique features and special cost estimation requirements of hydroelectric projects, proposes to identify cost overrun drivers from detailed examination of actual completion costs of projects, rank their importance and mutual relationships and evolve index of cost estimation reliability. Studying the pattern of cost overruns from case study of completed projects would help in identifying deficiencies in the existing cost estimation practices to suggest mitigation measures. Issues of climate change and water shortages have again brought hydroelectric projects to the front and thus it is important to study problems associated with their implementation.*

1. INFRASTRUCTURE PROJECTS:

Infrastructure development is a globally recognized index of development of any nation or region however there are variations in defining ‘ what all is covered under infrastructure ‘ not only among Nations but also within different organizations within a nation. **Cambridge dictionary** defines Infrastructure as “the basic systems and services, such as transport and power supplies, that a country or organization uses in order to work effectively”.The Niti Aayog (erstwhile Planning Commission) in 2008, through its subcommittee on Infrastructure suggested including the following in the broad definition of infrastructure:

i. Electricity (including generation, transmission and distribution) and R&M of power stations,
ii. Non-Conventional Energy (including wind energy and solar energy),
iii. Water supply and sanitation (including solid waste management, drainage and sewerage) and street lighting,
iv. Telecommunications,
v. Roads & bridges,
vi. Ports,
vii. Inland waterways,
viii. Airports,
ix. Railways (including rolling stock and mass transit system),
x. Irrigation (including watershed development),
xi. Storage,
xii. Oil and gas pipeline networks.

The World Bank treats power, water supply, sewerage, communication, roads & bridges, ports, airports, railways, housing, urban services, oil/gas production and mining sectors as infrastructure. In this age of specialization, construction projects have become

very extensively multidisciplinary and thus increased project management risks with regard to synergizing the conflicting interests of all. Major infrastructure projects generally have the following characteristics **(Flyvberg, 2009)**: [3]

- Inherently risky owing to long planning horizons and complex interfaces.
- Technology and design are often non-standard.
- Decision making, planning and management are typically multi-actor processes with conflicting interests.
- Often there is 'lock in' or 'capture' of a certain project concept at an early stage, leaving analysis of alternatives weak or absent.
- Project scope or ambition level will typically change significantly over time.
- Statistical evidence shows that such unplanned events are often unaccounted for, leaving budget and time contingencies sorely inadequate.
- As a consequence, misinformation about costs, benefits and risks is the norm through-out project development and decision making, including in the business case.
- The result is cost overruns and /or benefit shortfalls during project implementation.

Table 1: Popular Cost Overruns

No	Project	Extend of cost increase
1	Sydney Opera House	15 times higher
2	Concorde supersonic airplane	12 times higher
3	Suez canal (completed 1869)	20 times than the earliest costs and 3 times higher than the cost for the year before construction began
4	Panama canal (completed 1914)	in the range of 70 to 200%
5	Boston Big Dig (central artery / tunnel)	about 275%
6	Denver International Airport	close to 200%
7	San Francisco Oakland Bay Bridge retrofit	more than 100%
8	Channel tunnel	over 140%

(1-2: Hall, n.d. & 3-4: Summers, 1967, cited by Flyvberg, 2002) [1] ; 5,6,7,8-Flyvberg, 2005 [2]

2. DEVELOPMENT OF INFRASTRUCTURE PROJECTS IN INDIA

Modern day information technologies have shrunk the world as a global village. This has raised the aspirations and desires of masses even in very remote locations. Responding to the same Political leaders /decision makers set in very ambitious targets for infrastructure development. This is putting pressure on the limited capacity and capabilities of the delivering institutions and agencies in developing economies which ultimately results in repeated cost and time overruns along with poor quality and benefit shortfalls. The cost overruns are also being seen to be one of the significant causes for defaults of loans by project developers and the prevalent non-performing assets (NPA) crisis in Indian banking sector. Our banks stressed assets of around 12.47 trillion now stand at 9.6% of our GDP or about half of Budget 2018. Which in others words equals 46 times the health budget or 28 times the education budget **(Economic Times July 2018) [5]**

3. INHERENT RISK ACCUMULATION

The infrastructure projects due their high costs and long time lines are predominantly depended on public funding. They have thus to show high social values to establish viability and compete with other projects for early sanctions. Their success is thus based on political will of the government and thus are prone to risks associated with change of priorities of the governments of the day. Major challenges are :

a) Delay in Statutory clearances
b) Land acquisition , R&R , Forest & Environmental Issues
c) Law and order problems and Interruptions due to local agitations.
d) Scope changes , Cost and time overruns.
e) Funding risks and Shortfall of planned benefits.

Approach to risk mitigation would thus have to be project specific

4. PECULIARITY OF HYDROELECTRIC PROJECTS

Hydroelectric projects are highly capital intensive say around Rs 8 to 10 Crores per MW in India in present cost terms. These projects exhibit all the characteristics of big infrastructure projects described at 1.0 above. The cost management in such projects is even more complex because they are:

- Highly capital intensive, long construction schedules and relatively more material intensive.
- Location specific Project Design.
- No uniformity in scope and characteristics among projects of comparable magnitude.
- Varying Construction methodologies and schedules.
- Varying Rehabilitation and Resettlement Implications.
- Varying logistics and Infrastructural constraints.
- Varying Tax/Duty patterns, Labour Laws etc.

Hydroelectric Projects are mega projects which have 5-6 major work packages and multiple infra development projects of land, township development, approach roads, bridges etc. Each project is unique in itself. There could be projects which are quite concentrated spread over say 1-3 kms of travel or some widely scattered requiring travel between components of say 50-100 kms. There could be projects which have very limited underground work components and some which have long tunnels, underground caverns etc. There could be projects located quite close to rail heads say less than 50kms and some projects could be quite remotely located say 300-500 kms from nearest rail head. There are some locations where approach is restricted or cutoff for say 4-6 months in a year. Some projects might require shifting of big population / towns while some could have no displacement at all. Thus risk management strategies have to be project and location specific.

Table 2: Costing of Hydroelectric Projects in India

S. No	Project	Installed Capacity MW	Completion Cost in Crores	Mt-Year of Completion	Completion time in months	Cost per MW in Crores	Initial Unit cost in Rs/unit
1	Sewa-II (J&K)	120	1109	Jul-10	82	9.24	4.72
2	Chamera-III (H.P.)	231	2048	Jul-12	82	8.87	4.33
3	Chutak (J&K)	44	894	Feb-13	78	20.32	7.56
4	Nimoo Bazgo (J&K)	45	985	Oct-13	86	21.89	8.12
5	Uri-II (J&K)	240	2290	Oct-13	101	9.54	4.76
6	TLDP-III (W.B.)	132	1973	Mar-13	113	14.95	7.67
7	TLDP-IV (W.B.)	160	2405	Mar-16	131	15.03	7.41
8	Parbati-III (H.P.)	520	2612	Jun-14	103	5.02	9.43/ 3.37
9	Kishanganga (J&K)	330	5841	Apr-18	112	17.70	6

It is seen that the Cost/ MW and unit cost of generation for all the above projects show wide variation in spite of the fact that all of them are owned and managed by same organization ie NHPC ltd. The same speaks about the added complexity of hydro projects where no two projects can be compared until the site and project specific inputs are analyzed.

5. RISKS IN HYDROELECTRIC PROJECTS

The vulnerability of risks over project stages in hydroelectric projects as experienced by the author over his three decades of working in the sector are:-

Table 3: Risks Over Project Life Cycle

Project Stage	Risks
Field Investigations, Preparation of Detailed Project Report (DPR) and statutory clearances	Shortage of Capable & Experienced consultants
	Remotely located & Unapproachable sites
	Limited availability of Funds and time for DPR preparation.
	Delay in DPR preparation & processing of clearances

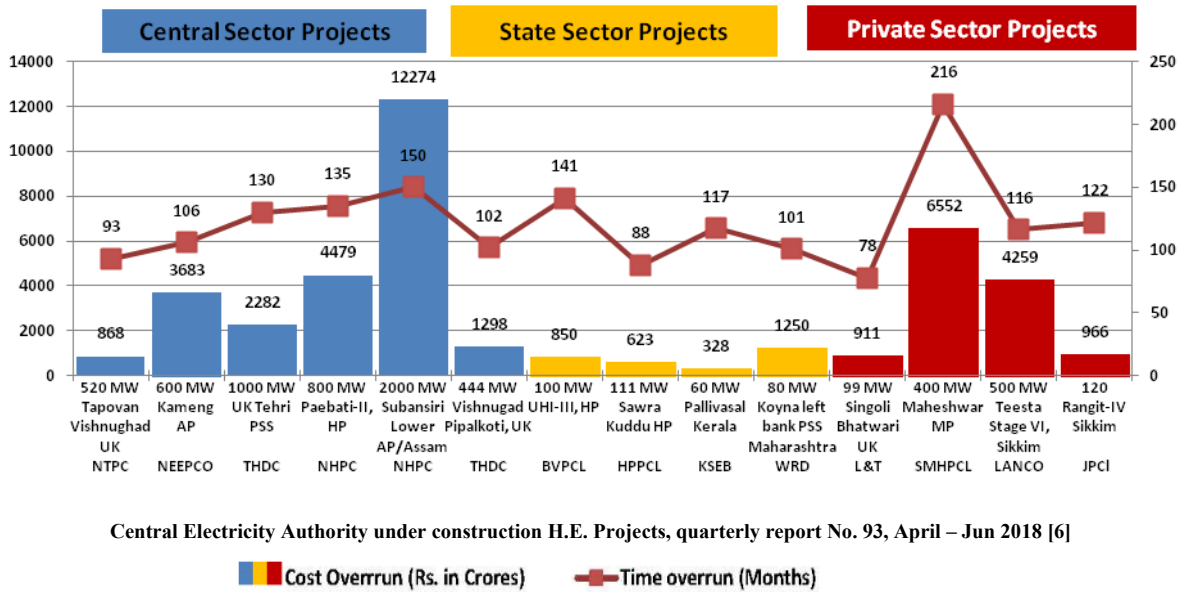
	Unrealistic Cost Estimation, schedules and benefits.
	Land Acquisition, local employment issues and R&R issues.
Financial Issues	Limited sources for long term funding of hydro projects
	High Nonperforming Assets (NPAs) in Banking sector
	Fluctuations in prices of materials & Inflation in economy
	High interest rates vs International funding
	Price variations over project implementation.
	Exchange rate fluctuations in foreign currencies
	Additional cost on a/c of Time and cost overruns
	Global Impacts due to slowdown/surge in demands
Procurement and Award of Works	Shortage of experienced & resourceful contractors & suppliers.
	EPC vs Package wise (Item rate) mode of procurement
	Appetite of market and competition during bidding.
	Insolvency of contractors & organizations.
	Limited efforts for Vendor Development
	Delays in Disputes Resolution & Arbitrations
	Absence of Risk Sharing mechanisms ie FIDIC vs local tender conditions.
	Variation during Award of works , CVC guidelines (L-1 Bids)
Construction Phase	Decision Making ie Delegation of Powers and Project Management Skills of Implementing Organization like Maharatna, Mini Ratna PSUs etc
	Design Changes due to site conditions. Quantity variations & Extra items.
	Logistic constraints like non availability of approach roads/ bridges to work sites. Constraints on fast movement of men, materials and machinery.
	Geological surprises like shear zones, cavities, and artesian aquifers like in Parbati II.
	Natural disasters like floods. Cloud bursts, earthquakes, rock falls, shooting stones
	Claims / court cases by contractors.
	Cases by NGOs/ local groups against project execution like in Subansiri Project.
	Adverse climatic conditions, heavy snowfall, lack of oxygen level reducing efficiency of men and machinery like Leh & Kargil region of J&K
	Shortage of skilled Labour for remotely located projects
	law & order problems e.g. J&K, North East Projects.
	International & inter state disputes like Indus water treaty with Pakistan.
Operation & Maintenance Phase	Change in laws & regulations- Central Electricity regulatory Commission (CERC) norms, Environmental flows, Water cess, Taxation etc
	Grid connectivity
	Hydrological Risks

6. COST OVERRUN IN HYDROELECTRIC PROJECTS :

Table 4: Global Scenario

S. No.	Date	Name of Project	Country	Cost Overrun (%)
1	2006	Sardar Sarowar Dam	India	513
2	2011	Bakun HE Project	Malaysia	417
3	2012	Three Gorges Dam	China	402
4	1978	Sayano-Shu Shenskaya	Russia	353
5	1979	La Grande 2	Canada	246
6	1976	Nurek	Tajikistan	200
7	1950	Vinstra	Norway	190
8	1977	Kariba Stage 2	Zambia/Zimbabwe	177
9	1981	Robert-Bourassa	Canada	143
10	1986	Chixoy	Guatemala	136
11	2009	Langtan Dam	China	113
12	1986	Guri (Raul Leoni)	Venezuela	101
13	1986	Third Power	Swaziland	100

Source : (Sovacool et al., 2014) [4]



Central Electricity Authority under construction H.E. Projects, quarterly report No. 93, April – Jun 2018 [6]

Figure 1: Cost Overrun in Indian Projects

On examination of the data, it is evident that hydroelectric projects show cost and time overruns regardless of their location, size or installed capacity and modes of execution. The variation in figures among projects could be due to the stage of completion of project at the time of reporting.

7. RESEARCH GAPS

Based on the existing literature studies, it appears that cost overruns are an old global phenomenon, seen with varying dimensions across the different types of projects. Globally the cost overruns of hydroelectric projects are on the higher side compared to other infrastructure projects primarily due to their long construction duration which make them more susceptible to technical, financial and regulatory risks. There is limited availability of reliable and documented cost details over the complete project cycle from approval to completion stage. Most of the existing research is based on surveys and interviews of stakeholders and there is urgent need for further research for reliable and documented reporting of actual cost details of projects. Over the years there appears to be very limited improvement or reduction of cost overruns in projects. There is wide appreciation of repeated occurrence of cost overruns and major contributing factors but studies based on data and detailed examination of case studies of completed projects for mitigating deficiencies in estimation practices across various types of projects are quite limited. Detailed study of planned and actual costs are expected to abridge significant knowledge gap with regard to resulting overruns and to suggest improvements in estimation practices .

The significance of the research is that presently only about 31 % of the Indian hydroelectric capacity has been harnessed. Issues of climate change and water shortages are forcing substitution of fossil fuel power sources with renewable sources including hydroelectric plants. Thus it is now more important to study the problem associated with implementation of hydroelectric projects.

8. APPROACH TO STUDY COST OVERRUN IN HYDROELECTRIC PROJECTS

Research mythology proposed for the study is shown in figure 2. Outputs of the study would be in form of ratings of cost overrun drivers and development of Index of Cost estimation reliability to suggest improvements in estimation practices.

9. CONCLUSIONS

The purpose of this study was to examine through literature study the problem of repeated cost overruns in hydroelectric projects and to identify gaps for future research. It is found that there is limited availability of reliable and documented cost details of completed projects. Most of the existing work is based on surveys and interviews. The study recommends the need for detailed examination of cost overrun from completed projects and to identify the cost overrun drivers, their rankings and mutual relationships. The findings could help in suggesting improvements in existing estimation practices.

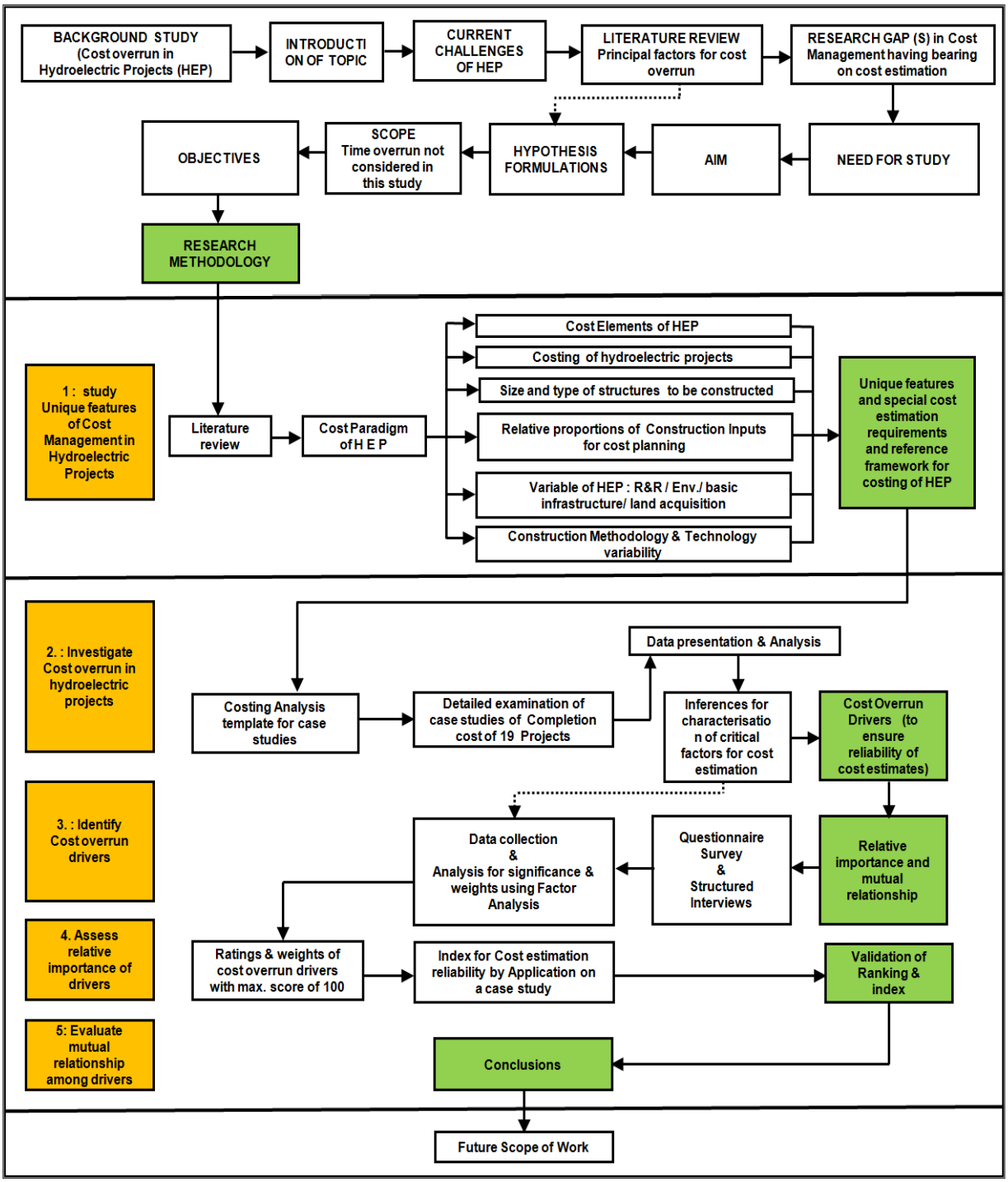


Figure 2: Research Mythology

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