

SUPPLEMENTARY MATERIAL A – List of Software Reviewed for the Determination of System Functions in the Proposed Prototype

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SUPPLEMENTARY MATERIAL B – PPP Risk Factors Used in the Proposed Prototype (Adapted from Authors [92])

***Risk factors that are integrated into the model after expert validation via Delphi Technique**

-LAND RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#
Initial Land Approval Risks (Pre-contract) *						x	x							x			3
Future Land Approval Risks (Post-contract) *														x			1
Land Availability/Acquisition Risks*		x	x			x		x			x			x			6
Land Acquisition Delay*												x	x	x			3
Additional Land Need Risk*														x			1
Heritage/Indigenous Rights*				x					x				x	x			4
Site Security Risks*														x			1
Site Access Risk*														x			1
Site Condition/Inappropriate Land*		x	x	x				x		x				x			6
Utility Risks *											x		x	x	x		4
Findings on Site (e.g. Archaeological) *									x					x			2
Munition/Mine/Bomb on Site														x			1
Polluted Site *														x			1
Available/Existing Asset Related Risks*								x						x			2
-FINANCIAL RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#
Finance Source Unavailability*	x	x			x	x	x	x		x	x				x		9
Financial Close Delay*										x							1
Inflation *	x	x	x	x		x	x	x	x	x	x	x	x	x			13
Exchange Rate Risk*		x	x			x	x		x	x	x	x		x			9
Interest Rate Risk*	x	x	x	x		x	x	x	x	x	x	x		x	x		13
Credit Risks*		x							x								2
Refinancing Risk*											x			x			2
Monetary Policy Radical Changes *			x														1
Tax Change*	x	x	x	x		x		x		x		x	x	x			10
Economic Conjuncture	x	x									x						3
Economic Sabotage/Sanctions*													x				1
Revenue Risk*	x	x		x					x						x		5
Low Rate of Return		x															1
Treasury guarantee risk*																x	1
Uninsurable Events *														x			1
Currency Convertibility Risk											x						1
-LEGAL AND CONTRACTUAL RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#
Partnership Formation-related Risk																x	1
Imperfect Legal/Law System*							x	x							x		3
Regulatory Compliance Risk*		x									x		x	x			4
Imperfect Contract*			x			x	x				x						4
Imperfect Specification *				x					x								2
Change in Law *	x	x		x		x			x	x		x	x		x		9
Court Order/Injunction*													x				1
Major Changes*						x	x	x				x	x	x			6
Disputes and Litigations*									x		x			x			3
Contracting Authority Status Change *																x	1
Private Partner Ownership Structure Change						x								x			2

Intellectual Property Infringement															x			1
Contrating Authority Step-in *															x			1
Abandonment of Project *						x			x									2
Contract Renegotiation Risk*																	x	1
Contract Termination *				x							x		x	x				4
-GOVERNANCE RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Feasibility Risks*					x	x												2
Non-competitive Tender *					x	x	x											3
Non-transparent Tender (Corruption)*					x	x	x	x			x	x				x		7
Public Investment Framework Risks*					x													1
Non Committed Public Party *		x			x			x				x				x		5
Inefficient Political Decision System*	x	x			x	x	x					x				x		7
Inefficient Approval Process *												x				x		2
Hiding Contract Information from Society*																	x	1
-POLITICAL RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Non-transparency During Project*					x													1
Government Intervention *				x		x	x	x		x	x	x	x					8
Material Adverse Government Action *															x			1
Political Inconsistency *	x	x	x		x	x			x		x	x				x		9
Compulsory Expropriation	x	x		x		x		x			x		x					7
Political Instability *		x						x			x							3
Civil Commotion/Riot *													x					1
War *			x											x	x			3
Blockade *														x				1
Militant Action/Terror *														x	x			2
-SOCIAL RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Negative Impact (Society/Business World)*															x			1
Social Opposition	x	x						x							x			4
Local People-Related Risks*															x			1
Relocation Risk *										x					x			2
Strike																x		1
-DESIGN RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Design Delay		x	x															2
Design Approval Risks*		x													x			2
Design Deficiency/Unsuitability *	x	x	x	x				x		x	x	x	x	x				10
Design Change *	x	x													x			3
-ENVIRONMENT & FORCE MAJEURE-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Incompatibility with Standards*					x													1
Environmental Approvals Related Risks*															x			1
Environmental Harm*						x		x	x			x				x		5
Environmental Event	x	x	x			x		x				x			x	x		8
Force Majeure *		x	x	x		x		x	x	x	x	x	x			x		11
-CONSTRUCTION RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Long Time Delay at Project Start																	x	1
Long Time Stop During Project*																	x	1
Cost Increase*	x	x		x				x	x	x	x	x			x	x		10

Delay Risk*	x	x		x					x	x	x	x	x		x			9
Performance Risk*										x								1
Incompatibility with Standards *									x	x								2
Defects *				x					x						x			3
Material/Input Risks (Quantity Related)	x	x				x		x	x				x					6
Material/Input Risks (Quality Related)		x	x			x		x	x				x					6
Material/Input Risks (Time Related)		x				x		x	x				x					5
Restriction on Import/Export				x														1
Construction Material Price Change *				x		x	x		x									4
Inadequate Human Resource	x	x																2
Inadequate Labor	x	x	x			x		x	x				x					7
Severe Changes in Labor Costs*																	x	1
Technology Risks					x				x			x	x		x			5
Inexperienced Stakeholders	x	x				x		x				x	x					6
Imperfect Supervision*						x	x											2
Organization/Coordination Risk	x	x				x		x								x		5
Private Partner Insolvency *															x			1
Subcontractor Insolvency		x	x												x			3
Interface Risk (Construction)															x			1
Health and Safety Risk (Construction)								x							x			2
Vandal Actions (Construction)															x			1
-OPERATIONAL & TRANSFER RISKS-	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	#	
Low Demand*	x	x	x	x		x	x	x		x	x	x		x	x		12	
High Demand *	x		x			x	x	x		x	x	x		x	x		10	
Monopoly Risk																x	1	
Insufficient Income Risk																x	1	
Competition Risk (Competitive Projects)		x	x			x			x				x		x		6	
Tariff Protest													x				1	
Tariff Change *										x	x	x			x		4	
Operational Material Risks															x		1	
Operational Labor Risks															x		1	
Operational Human Resource Risks															x		1	
Operational Cost Increase	x	x				x	x	x		x	x	x		x			9	
Operational Performance Quality Risks*				x				x		x	x			x			5	
Operational Interruption				x						x							2	
Operational Resource Supply Risk															x		1	
Maintenance Risks *	x	x						x					x				4	
Health and Safety Risk (Operation)				x													1	
Interface Risk (Operation) *															x		1	
Vandal Actions (Operation)															x		1	
Embargo *													x	x			2	
Facility Condition Risk During Transfer									x						x		2	

¹Bing et al. (2005); ² Ibrahim et al. (2006); ³Abednego and Ogunlana (2006); ⁴Ng and Loosemore (2007); ⁵Zou et al. (2008); ⁶Xu et al. (2010); ⁷Cheung and Chan (2011); ⁸Hwang et al. (2013); ⁹Wojewnik-Filipkowska and Trojanowski (2013); ¹⁰Carbonara et al. (2015); ¹¹Ameyaw and Chan (2015); ¹²Osei-Kyei and Chan (2017); ¹³Opawole and Jagboro (2018); ¹⁴GI HUB (2019); ¹⁵Wang et al. (2020) ¹⁶ Additional risk factors identified during expert validation via Delphi Technique

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SUPPLEMENTARY MATERIAL C – PPP Project Information Requirements Used in the Proposed Prototype (Adapted from Authors [93])

*** Project Information Requirements that are integrated into the model after expert validation via Delphi Technique**

-General Project Information-	Source No and (Page)
Project Description and Scope*	11(p.440)-13(p.84)
PPP Type*	4(p.256)
Public Party*	8(p.38)-12(p.6)
Sponsor*	8(p.38)-12(p.6)
Lenders*	3(p.6)-8(p.38)
Consultant	8(p.38)
Suppliers	12(p.6)
Contractors*	12(p.6)
Operator*	12(p.6)
Users*	8(p.38)
Other Stakeholder (Unions, Media etc.)	8(p.38)-12(p.6)
-Contract General Information-	Source No and (Page)
Bid Submission Date/Tender Date*	1(p.272)-3(p.5)-6(p.22)
Implementation Contract Signing Date*	14
Contract Effective Date*	14
Contract Type*	1(p.272)-6(p.20)
Construction Period*	4(p.256)-6(p.222)-10(p.143)
Operation Period*	14
Concession Period*	4(p.256)-6(p.222)-10(p.143)
Repayment Period*	1(p.236)-7(p.253)
Expiry Date*	2(p.2)-3(p.10)
-Finance and Insurance and Warranties-	Source Numbers and (Page)
Currency*	3(p.9)-6(p.253)
Private Party Shareholders Percentages*	14
Equity/Debt Ratio	5(p.31)
Loan Financing*	1(p.272)
Repayment Program/plan*	14
Recourse-non Recourse	1(p.228)
Insurance*	2(p.19)-3(p.80)-4(256)-10(p.143)
Escrow*	1(p.136)-6(213)
Contingency*	6(214)
Guarantees, Warranties, Performance Bonds*	6(214)
-Legal and Technic-	Source No and (Page)
Laws*	2(p.10)-3(p.10)
Regulations*	3(p.10)
Permits, Consents, License*	2(p.10)-3(p.19)
Quality standards*	3(Annex 12)
Specifications*	2(p.10)-3(Annex 13)
Guidelines*	14
Intellectual Property Rights *	2(p.38)-3(p.95)
-Project General Analysis-	Source No and (Page)
Value Proposition*	13(p.252)
Milestones*	13(p.241)
Success Criteria*	13(p.96)
Boundaries/Constraints*	11(p.440)-13(p.174)
Assumptions*	11(p.440)-13(p.174)
Strengths*	11(p.394)-13(p.177)
Weaknesses*	11(p.394)-13(p.177)
Opportunities	11(p.394)-13(p.177)
Threats*	11(p.394)-13(p.177)
-Mechanisms and Provisions-	Source No and (Page)
Rate/Tariff Adjustment Mechanism*	5(p.31)-10(p.143)
Revenue sharing mechanism*	14
Exclusivity Provisions*	3(p.23)
Compensation Cases*	2(p.50)-6(p.198)-9(p.64)
Relief Events*	2(p.29)-6(p.198)-9(p.17)

Force Majeure*	2(p.31)-3(p.83)-6(p.224)-9(p.15)
Extension of Time Conditions*	2(p.3)-3(p.40)-9(p.23)
Dispute Resolution Mechanisms*	2(p.53)-3(p.99)-9(p.107)
Early Termination Provisions*	2(p.50)-3(p.85-87)-9(p.24)
Early Termination Payments*	2(p.50)-3(p.89)-6(230)-9(p.61)
Handback requirements*	14
Defects Liability Period Provisions*	3(p.7)-6(p.198)
Sources; ¹ Akintoye et al. (2003), ² Fort St. John Hosp. Agreement (2009), ³ Kosovo Airport PPP Contract (2010), ⁴ Yuan et al. (2012), ⁵ Ogunsanmi (2013), ⁶ Boussabaine (2013), ⁷ Chen et al. (2015), ⁸ APMG (2016), ⁹ IBRD and Worldbank (2017), ¹⁰ Mohamad et al. (2018), ¹¹ Richards (2018), ¹² Wojewnik-Filipkowska and Węgrzyn (2019), ¹³ PMBOK 7th (2021) ¹⁴ Additional information requirements identified during expert validation via Delphi Technique	

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SUPPLEMENTARY MATERIAL D – PPP Financial Information Requirements Used in the Proposed Prototype (Adapted from Authors [93])

* Financial Information Requirements that are integrated into the model after expert validation via Delphi Technique

Financial Information Requirements	1	2	3	4	5	6
Demand Projection*	X	X	X		X	X
Tariff/Toll Level*	X	X	X	X	X	X
Initial Working Capital*	X	X		X	X	
Amount (Loan)*	X	X	X		X	X
Maturity*	X	X	X	X		
Debt/Equity*		X	X	X		
Inflation*	X	X	X	X		X
Interest Rate*	X	X	X	X	X	X
Exchange Rate*	X	X	X	X	X	X
Project Costs*	X	X	X	X	X	
Financing Cost*	X	X	X	X	X	X
Construction Cost*	X	X	X	X	X	X
Operational Cost*	X	X	X	X	X	X
Maintenance Cost*	X	X	X	X	X	X
Tax*	X	X	X	X	X	X
Depreciation*		X	X			X
CAPEX*	X	X	X	X		X
Contingent Liabilities*	X		X			X
Contingency Funding*	X	X	X	X		
Revenue*	X	X	X	X	X	X
CFADS (Cash flow for debt service)*		X	X	X	X	X
Net Cash Flow*	X	X	X	X	X	X
EBITDA *		X	X		X	X
NPV (Net Present Value)*	X	X	X	X	X	X
IRR (Internal Rate of Return)*	X	X	X	X	X	X
ROI (Return on Investment)	X	X	X	X		
ROE (Return on Equity)*	X	X	X	X	X	
WACC (Weighted Average of Cost of Capital)	X	X	X	X		
Interest Covering Ratio*		X			X	
DSCR (Debt Service Cover Ratio)*	X		X	X	X	
ADSCR (Annual Debt Service Cover Ratio)*	X	X	X	X		
LLCR (Loan Life Cover Ratio)*	X	X	X	X	X	
PLCR (Project Life Coverage Ratio)*	X	X	X	X		
References; ¹ Grimsey and Lewis (2004), ² Yescombe (2007), ³ PPIAF (2009), ⁴ Boussabaine (2014), ⁵ Kurniawan et al. (2015), ⁶ IMF and World Bank (2022)						

References for Supplementary Material D

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SUPPLEMENTARY MATERIAL E - Expert Profile Participated in the Delphi Study Conducted for Risk Factors Determination - Adapted from Authors [92]

Experts	PPP Experience	Number of PPP Projects
Expert 1	7	4
Expert 2	20	20
Expert 3	6	7
Expert 4	5	8
Expert 5	12	15
Expert 6	25	20
Expert 7	25	50
Expert 8	7	11
Expert 9	8	8
Expert 10	5	10
Expert 11	10	5
Expert 12	20	15
Expert 13	10	50
Average	>12	>17

SUPPLEMENTARY MATERIAL F – Expert Profile Participated in the Delphi Study Conducted for Information Requirements Determination (Adapted from Authors [93])

Experts	PPP Experience	Number of PPP Projects
Expert 1	20	20
Expert 2	9	7
Expert 3	3	4
Expert 4	17	40
Expert 5	13	Not Stated
Expert 6	15	20
Expert 7	10	10
Expert 8	5	3
Expert 9	Not Stated	Not Stated
Expert 10	10	5
Expert 11	12	5
Expert 12	15	30
Average	>11	>14

*"Not stated" cells not included in the average

SUPPLEMENTARY MATERIAL G – Expert Profile Participated in the Verification and Validation of the Proposed Prototype

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16	P17	P18	P19	P20	P21
	Consultant	Consultant	Senior Engineer	Senior Project Consultant	Planning Engineer	Contract Consultant	Deputy Project Manager	Senior Planning Engineer	Contract Consultant	Consultant	Senior Planning Engineer	Contract Consultant	Consultant	Senior Project Manager	Project Manager	Senior Engineer	Consultant	Academician	Senior Project Manager	Academician	Academician
Total PPP Experience (Year)	20	11	5	6	4	30	9	5	25	20	3	27	28	-	32	-	20	-	6	23	-
Number of PPP Project Experience	50	15	2	20	1	10	2	1	4	15	2	12	13	-	1	-	3	-	1	2	-
Experience based on the PPP Sector	Energy	Road Energy	Hospital	Health Road	Hospital	Health Road	Hospital	Hospital	Road Airport	Energy	Hospital Rail	Road	Road Airport	Airport	Road	Health Airport	Road	Academic	Hospital	Road	Academic
Experience based on PPP Type	BOT	BOT Privatization	BOT	BOT	BOT	BOT	BLT	BOT	BOT	BOT	BOT	BOT-BLT	BOT-BLT	-	BOT	-	BOT	-	BOT	BOT	-
Expertise area (a-PPP, b-Risk management, c-Contract)	a-b-c	a-c	a-b-c	a-b	a-b	a-c	a-b-c	a-c	a-b-c	a-b-c	a	a-c	a-b	b-c	a	c	a-b-c	b-c	a-c	a-b-c	b-c

SUPPLEMENTARY MATERIAL H – Risk Register Items Explanations

Risk ID:	It is an identification code that the user assigns to recognize a risk. Numbers and letters can be used to create a Risk ID.
Risk contract clause ID:	It is the identification number of contract clauses that are related to the assessed risk. It is used to make associations between project risks and contracts.
Category (Type):	The group where the risk is listed (e.g., Financial, Political, Social, etc.)
Project phase:	It is used to define in which project phases the risk can be seen. For instance, Revenue risk can be seen in the Operation phase. Assigning multiple project phases to risks is possible since some risks can be seen in more than one project phase.
Description:	Detailed description of the risks and detailed explanation of the mechanisms used against the risks.
Probability score:	The probability assessment of the risk on a 1-10 scale.
Impact score:	The impact assessment of the risk on a 1-10 scale.
Probability x Impact:	It is the multiplication of the Probability and Impact scores.
Impact type:	It defines the risk's impact kind on the project. For instance, Site Security risks can cause delays. Hence, the impact type of the Site Security risk is "Time Impact". It is possible to assign more than one impact type to a risk.
Risk cost impact:	It is the impact of a risk on the project in terms of cost.
Risk time impact:	It is the impact of a risk on the project in terms of time.
Strategy:	The applied strategy against the risks (e.g., Avoid, Accept, Share, Transfer, etc.)
Allocation:	The party in the project that undertakes the risk.
Risk owner:	The responsible person from the party undertaking the risk.
Mitigation/Prevention:	Mechanisms and actions to prevent risks or to reduce the risk impact.
Compensation:	Mechanisms and actions that will be applied when a risk event occurs (e.g., Monetary Compensation, Extension of Time)
Causal risk:	The risk or risks that cause the occurrence of another risk.
Consequential risk:	The risk or risks occurring due to another risk.
Residual risk:	The risk or risks that remains even if mitigation actions are implemented.
Secondary risk:	The risk or risks that occur due to the applied risk mitigations.
Author:	The person filling in the details on the risk register.
Risk entry date:	The date when the risk is added to the system. It is assigned by the system automatically.
Risk revision date:	The date when a revision is made on the risk. It is assigned by the system automatically.
Risk status:	It shows the current status of a risk and is used to monitor risks (e.g., Active, Closed, Waiting, etc.)