AN EFFECTIVE RISK AND UNCERTAINTY MANAGEMENT PROCESS FOR INFRASTRUCTURE PROJECTS: DEVELOPMENT OF MULTI-PARTY RISK AND UNCERTAINTY MANAGEMENT PROCESS

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***ABSTRACT*:** With the attention on poor project goal achievement such as severe delay of many infrastructure projects due to various problematic and potential risks and uncertainties, risk management process (RMP) have been introduced to deal with those risks impacting the project objectives. However, there are still fundamental and technical limitations associated with previously proposed RMPs. As a result, they may not fully provide efficient way in managing risks and uncertainties successfully in real world projects. To overcome limitations associated with conventional RMPs, an effective risk and uncertainty management process has been developed called multi-party risk and uncertainty management process (MRUMP). This paper describes the development of the MRUMP and its associated deliverables to deal with stated limitations of conventional RMPs in order to systematically and efficiently manage risk and uncertainty inherent in infrastructure projects.

KEYWORDS: risk and uncertainty, risk management process, multi-party environment in infrastructure projects

1. INTRODUCTION

Inevitably, risks and uncertainties are substantially inherent in infrastructure projects. Problematically, many infrastructure projects not limited to Southeast Asian countries could not have achieved project goals satisfactorily. One of the most frequent failures is severe project delay and cost overrun. Their major reason is the occurrence of external and internal project risks and uncertainties throughout project stages i.e., from planning, bidding, contracting to construction. As a result, many projects completed with poor project performance.

It is still questionable about why this phenomenon of project failure has been occurring. Thus, following sub-sequential questions come and wait for answers. What are common risks and uncertainties inherent in projects? How are they conventionally managed? Are there any limitations associated with these conventional approaches? If there are, how they should be improved? This paper attempts to answer these questions.

2. COMMON RISK FACTORS

Before moving forward, the definition of term ‘risk’ and ‘uncertainty’ used in this paper is discussed. In this paper, the risk management is examined in the context of project management. Risk and uncertainty are characterized into three components i.e., 1) risk/uncertainty event, 2) probability of occurrence, and 3) outcome: potential loss/gain. Importantly, the definition of risk and uncertainty are basically different based on “position” of parties in a project.

Here the terms "risk" and "uncertainty" are defined as follows. "Risk" means the event/condition such that a) its occurrence is identifiable, b) it brings negative effect to project objective, c) the probability distribution of outcome of the event is quantifiable, and d) it is controllable by one party. "Uncertainty" means the event/condition such that a) its occurrence is unidentifiable, b) it may bring positive or negative effect to project objective, c) the probability distribution of outcome of the event is unquantifiable, or d) it is uncontrollable by one party. This definition of risk and uncertainty is referred throughout the paper.

After we understand the definition of risk and uncertainty, we are attempting to answer the first question regarding common risks and uncertainties. Especially, in real infrastructure projects, though practitioners think that they have elaborately planned and organized projects at early stage, they still possibly encounter undesirable outcomes during a project. At least there are two reasons for this phenomenon. First, conditions of projects themselves induce risky and uncertain situations. Second, uncontrollable and unexpected events likely occur when it is considered that these events should be ignored. These occur because practitioners have limited experiences to foresee these undesirable events. Project risk and uncertainty management is not conducted properly at the first hand.

Regarding the first reason, conditions, which induce risks and uncertainties to projects, may be different from project to project. However, a number of conditions are considered common in several infrastructure projects, including:

1) very tight project objectives;
2) limited resources;
3) limited capability and experience of practitioners;
4) long project period (more than 1 year); and
5) many parties are involved directly or indirectly.

Furthermore, there are still other risk and uncertain factors that cause poor project performance. For example, the causes of delay of several infrastructure projects in Thailand are summarized in the following list (Jaisue 2009):

A. causes from project site
   - A1) inconvenient site access
   - A2) limited construction area
B. causes from project owner
   - B1) delays in decision making
   - B2) postponement of project
   - B3) design changes
   - B4) delays in payment
   - B5) late land hand-over
   - B6) late submission of nominated materials
C. causes from designer
   - C1) late design works
   - C2) mistake in design
   - C3) inappropriate design
D. causes from consultant
   - D1) unreasonable project time frame
   - D2) late inspection
   - D3) late documentation
   - D4) late approval
E. causes from contractor
   - E1) delay in commencement
   - E2) insufficient inspectors
   - E3) incapable inspectors
   - E4) insufficient labors
   - E5) rework from poor material quality
   - E6) rework from poor workmanship
   - E7) financial problem
   - E8) internal administrative problems
   - E9) improper construction method
   - E10) disturbance to public activities
F. causes from public agency
   - F1) late issuing of approval documents
G. causes from external factors
   - G1) natural disaster

G2) politic

G3) economic

Practitioners should find ways to deal with these risk and uncertain conditions of projects as well as common risks and uncertainties influencing project performance.

2. RISK MANAGEMENT PROCESS

To deal with previously identified common risks, traditional approach for risk treatment relies mostly on intuitive and rule of thumb, which is not necessarily logical. Then, conventional risk management process (RMP), which is considered systematic, rational, logical, and proactive approach, has been introduced to assist a decision-maker to manage risk systematically and efficiently (Al-Bahar and Crandall 1990; Flanagan and Norman 1993; Chapman and Ward 1997; ICE 1998; and Pipattanapiwong and Watanabe 2003; and PMI 2004).

Theoretically, the essence of the conventional RMP is based on the risk efficiency concept (Chapman and Ward 1997), which illustrates the trade-off between risk (variance of impact) and expected impact of considering responses. Generally, the conventional RMPs consist of three main processes, i.e., risk identification process, risk analysis process, and risk response process. For example, project risk management in PMBOK consists of risk management planning process, risk identification process, qualitative risk analysis process, quantitative risk analysis process, risk response planning process, and risk monitoring and control process (PMI 2004).

Another state of art of risk management is framework of ISO 31000: risk management - principles and guidelines on implementation. This framework is still in elaboration process and is not yet published. It focuses on risk management in organization level and also emphasizes incorporation of risk perception from both internal and external stakeholders throughout its processes. Process for managing risks according to ISO 31000 comprises of communication and consultant process (interact with all processes), establishing the context, risk assessment (including risk identification, risk analysis, risk evaluation), risk treatment, and monitoring and reviewing process (iterate and interact with all processes) (ISO/TMB WG on Risk Management 2007).

Conventional RMPs provide explicit and better decisions for a decision-maker in making decision. They can provide a number of benefits e.g., reducing of risk exposures, preplanning and providing prompt response to risks, incorporating experience in analysis, and offering more explicit decisions. However, application of RMPs will not remove all risks. As far as the scope and application of conventional RMPs are concerned, there are still a number of fundamental and technical limitations that should be addressed.

3. LIMITATIONS OF RMP

To identify the limitations associated with the conventional RMPs, it is based on lessons learnt from development and application of previously proposed MRMP (Pipattanapiwong and Watanabe 2000) and further extensive literatures review. As a result, four major limitations, which are related to subjectivity, process, output interpretation, and scope were identified.

The fundamental and technical limitations associated with previously RMPs consist of

1) inattention on low-probability and high-impact event (which is often called ‘uncertainty’ event),

2) little established risk structuring and analysis procedure,

3) little established risk impact quantification procedure and interpretation difficulty of dimensionless output, and

4) insufficient involvement of multiple parties.

1) Inattention on 'uncertainty' event

Inattention on 'uncertainty' event is the first fundamental limitation. As previously mentioned, many practitioners may have limited ability to properly deal with risk/uncertainty because of limited experience, insufficient historical data or bounded rationality of human subjective assessment. Particularly, the event with low frequency of occurrence but extremely high impact, which is often called a "catastrophic event," is easy to be neglected.

It should also be noted that a typical rule to prioritize events in the conventional RMPs is the expected value of impact of each event. This implies that even if a certain "catastrophic" event is correctly identified, it may not be categorized as a major event with high priority if its expected value, the product of frequency of occurrence of the event and its impact, is low. In other words, the conventional RMPs have been designed for mainly dealing with the event with high probability and high impact.

2) Little established risk structuring and analysis procedures

The second limitation is related to technical issue of conventional RMPs. Generally, structuring framework to facilitate practitioners in specifying influential relationship among risks is not explicitly provided in the conventional RMPs. Practitioners have to structure risks without a general reference every time they have to do so. In such a way of structuring, there is a high possibility that practitioners neglect important risk events, leave causal relationship among identified events ambiguous, or end up with drawing too a complex risk structuring diagram. Usage of such an incomplete, ambiguous, and complex diagram may lead to low precision in the analysis and, thus, to wrong conclusions.

3) Little established risk impact quantification procedure and interpretation difficulty of dimensionless output

The next limitation is a difficulty in interpreting outputs of the conventional RMPs due to little established risk impact quantification. Normally, the main outputs of conventional RMPs are tradeoffs between the expected value and the variance of impact associated with each measure for major risks and uncertainties. Since these expected values and variances are generally represented with dimensionless values; however, practitioners cannot easily understand how many days the project would be delayed in average or in the worst case when each measure should be taken. If each party has this interpretation difficulty, smooth communication and discussions among parties would be hard to realize.

4) Insufficient involvement of multiple parties

For the fourth limitation, the conventional RMPs basically incorporate only single party's view in their scope and application. Views of multiple parties involved in the project are hard to be incorporated. A major cause of conflicts or problems among multiple parties is their different views towards risks and uncertainties. It is desirable, thus, to develop a method of facilitating mutual understanding among parties, identifying parties' differences and problems, and solving the problem.

4. DEVELOPMENT OF MRUMP

Aiming to overcome stated limitations of conventional RMPs, an effective risk and uncertainty management process called the "Multi-party Risk and Uncertainty Management Process (MRUMP)" was developed (Pipattanapiwong 2004). As a logical, systematic and concise tool, the MRUMP attempts to assist and facilitate practitioners managing risks and uncertainties under a multi-party project environment systematically and efficiently. The MRUMP consists of following major deliverables:

1) a prototype of risk/uncertainty map,
2) the hierarchical structure of risk and uncertainty (HSRU) framework,
3) the duration valuation process (DVP), and
4) integration of multiple views.

4.1 Risk/Uncertainty Map

To deal with the first limitation regarding insufficient attention on uncertainty, a prototype of risk/uncertainty map with initially focusing on infrastructure projects financed by international lenders was developed. The developed risk/uncertainty map aims to assist practitioners to better deal with risks and uncertainties by accumulating the experience and lessons from past projects and updating the risk and uncertainty structure whenever needed.

Two main sources of information were used in developing prototype of risk/uncertainty map, i.e., literatures for risks/uncertainties related to construction projects in general and results of case studies of three infrastructure projects financed by international lenders including subway construction project, bridge construction project and hydropower construction project. The prototype of risk/uncertainty map was developed based on the platform of risk and uncertainty breakdown structure (RUBS). There are 20 categories of uncertainties in four levels in the RUBS. Based on the categories in RUBS, a checklist of risks and uncertainties was developed. It consists of a number of risk factors and sub-factors. The prototype of risk/uncertainty map and RUBS associated with its risk/uncertainty checklist is considered as a tool for guiding practitioners to identify risks and uncertainties as completely as possible. The RUBS and prototype of risk/uncertainty map are shown in Figures 1 and 2, respectively. Both RUBS and risk/uncertainty checklist are two important tools used in risk identification and structure processes of the MRUMP.

4.2 Hierarchical Structure of Risk and Uncertainty

To overcome technical limitation regarding little established risk structuring and analysis procedures, a "standard" and "organized" risk structuring diagram called the "Hierarchical Structure of Risk and Uncertainty (HSRU)" framework was developed. In the HSRU framework, the cause and effect events are hierarchically separated. This framework aims to facilitate practitioners in clearly classifying identified risks and uncertainties into cause and effect events and logically assessing the occurrence probability of each event according to basic probability law such as the conditional probability and the multiplication theorem.

HSRU is divided into four main layers based on hierarchical flow of source, consequence, occurrence, and outcome from upper to lower layer respectively. The source layer contains source of risk/uncertainty. The consequence layer contains consequent risk/uncertainty. The occurrence layer contains influential risk/uncertainty and influenced activity. The outcome layer shows type of delay.

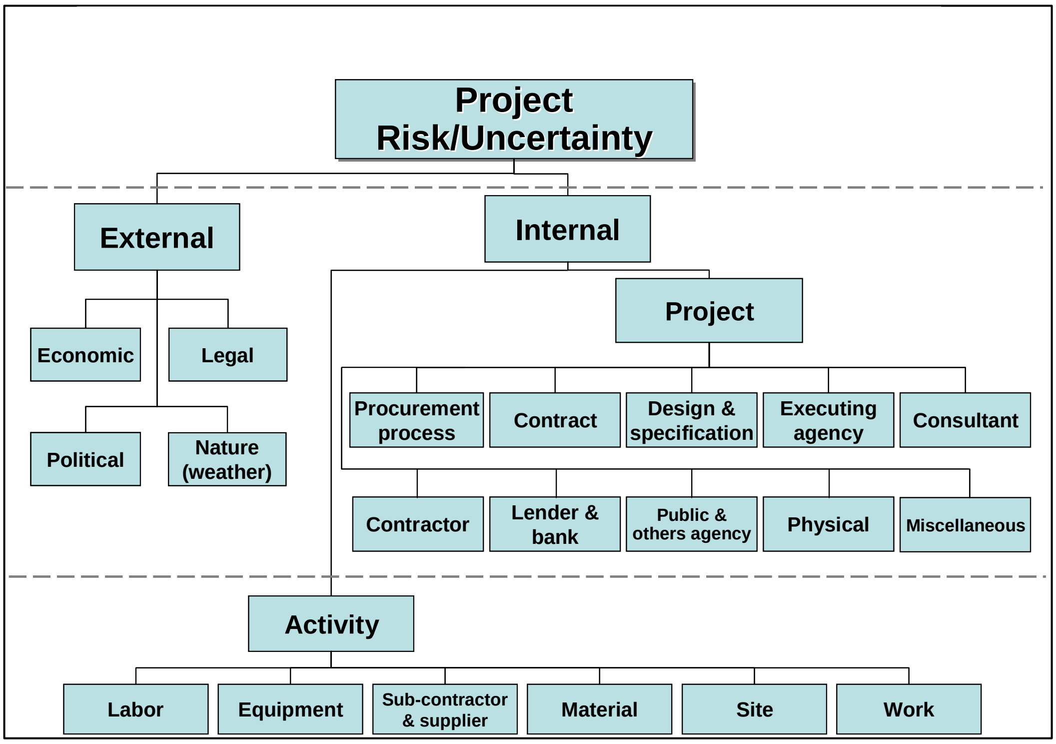

Figure 1 Risk and uncertainty breakdown structure

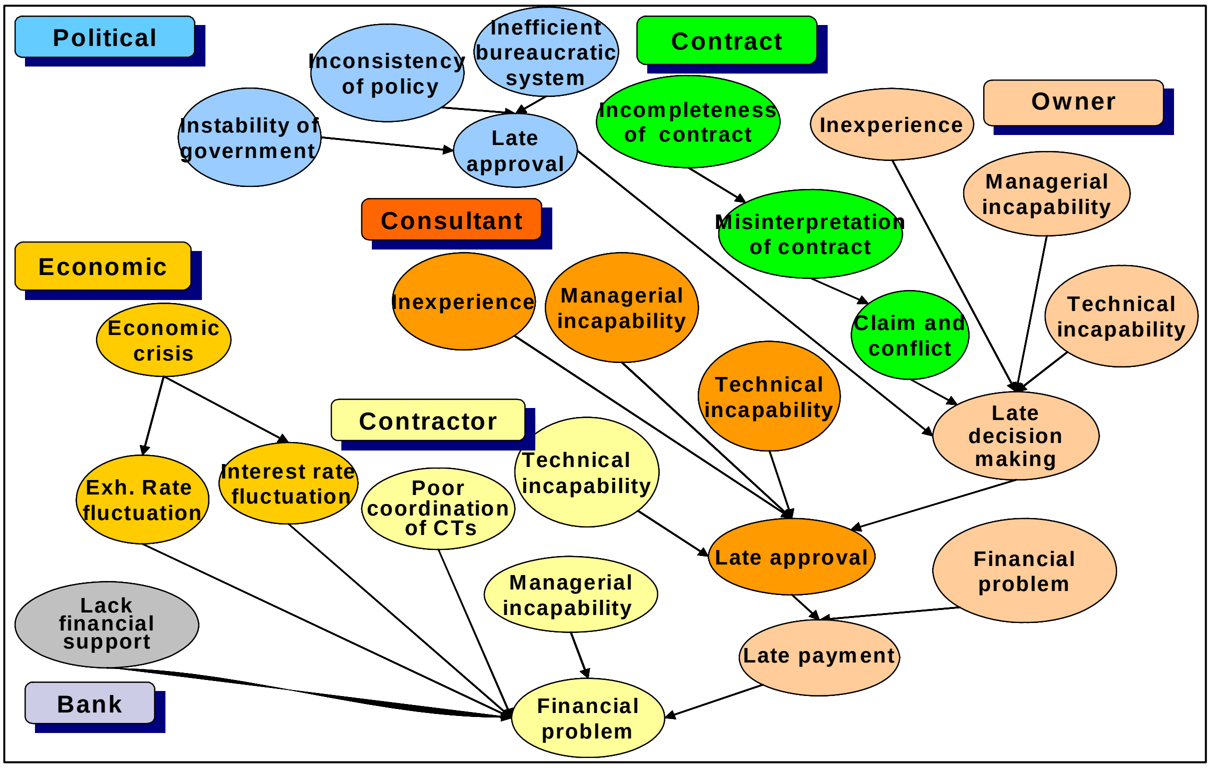

Figure 2 Prototype of risk/uncertainty map

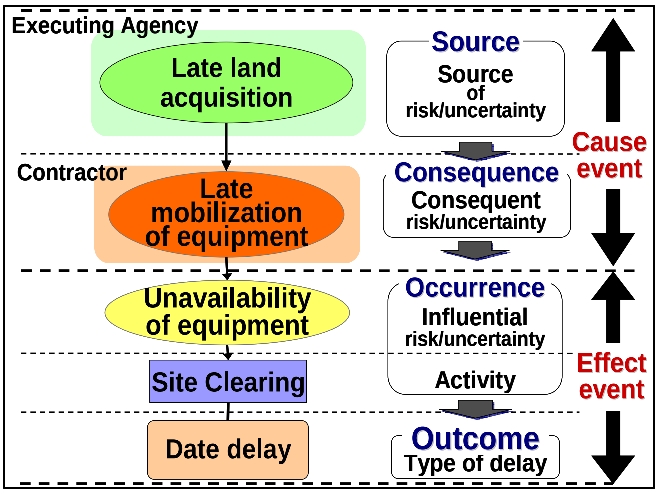

Figure 3 Example of hierarchical structure of risk and uncertainty

Based on the framework of HSRU, the cause event (including source and consequence layers) and effect event (including occurrence and outcome layers) can be obviously separated. An example of HSRU is shown in Figure 3.

4.3 Duration Valuation Process

To overcome the interpretation difficulty of dimensionless outputs due to little established risk impact quantification, the duration valuation process (DVP) was developed. Its output is the cumulative distribution of the project duration, and the main feature to give this dimensional output is logical and systematic assessment procedure of probability and impact of each risk and uncertainty. The DVP consists of four main processes (shown in Figure 4):

1) development of the HSRU,
2) assessment of occurrence probability of each event,
3) impact assessment of each event, and
4) simulation of the construction duration by using the Monte Carlo simulation.

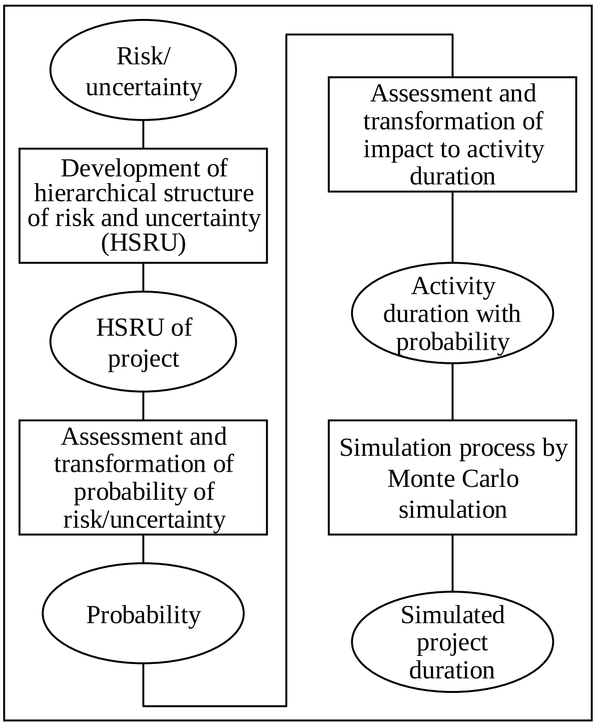

Figure 4 Input-process-output flow chart of DVP

In the DVP the occurrence probability of each event is actually assessed through asking practitioners questions designed based on the structured HSRU. Productivity concept, work breakdown structure and scheduling concept, and classification of delay such as total delay, date delay, and progress delay are employed as the basis in quantification of impact in terms of days.

4.4 MRUMP

As an initial step to challenge the limitation regarding insufficient incorporation of multiple parties' views, Pipattanapiwong and Watanabe (2000) developed the "Multi-party Risk Management Process (MRMP)." From the MRMP application, each party's view for mutual "reference" was obtained. However, to obtain a reference is just a first step to manage risk and uncertainty in a project. To complete management, it is necessary to go through the following processes: problem awareness of understanding from the reference that

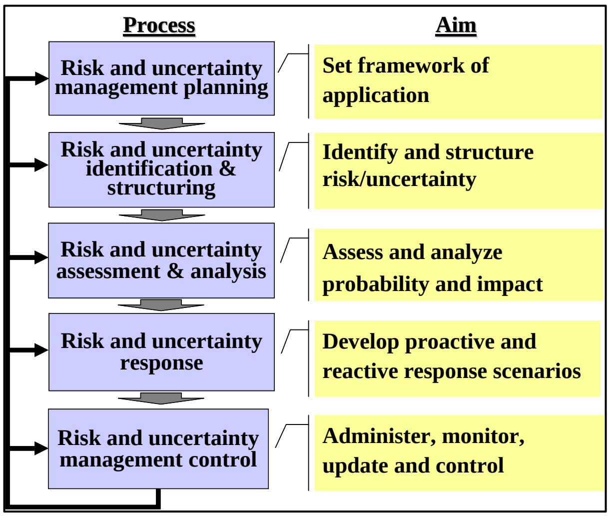

Figure 5 Multi-party risk and uncertainty management process

each party's view can be very different, problem identification of understanding through communicating each other where the difference exists, and problem solving by integrating views of parties. Thus, the MRUMP has new functions of identifying problems and integrating multiple parties' views.

After development of main components described previously, they are assembled and packaged in the MRUMP. The MRUMP consists of five main systematic processes ranging from risk and uncertainty management planning, identification and structuring, assessment and analysis, response, and control processes. Figure 5 shows processes of the MRUMP and their aims. Figure 6 summarizes inputs and outputs of each process.

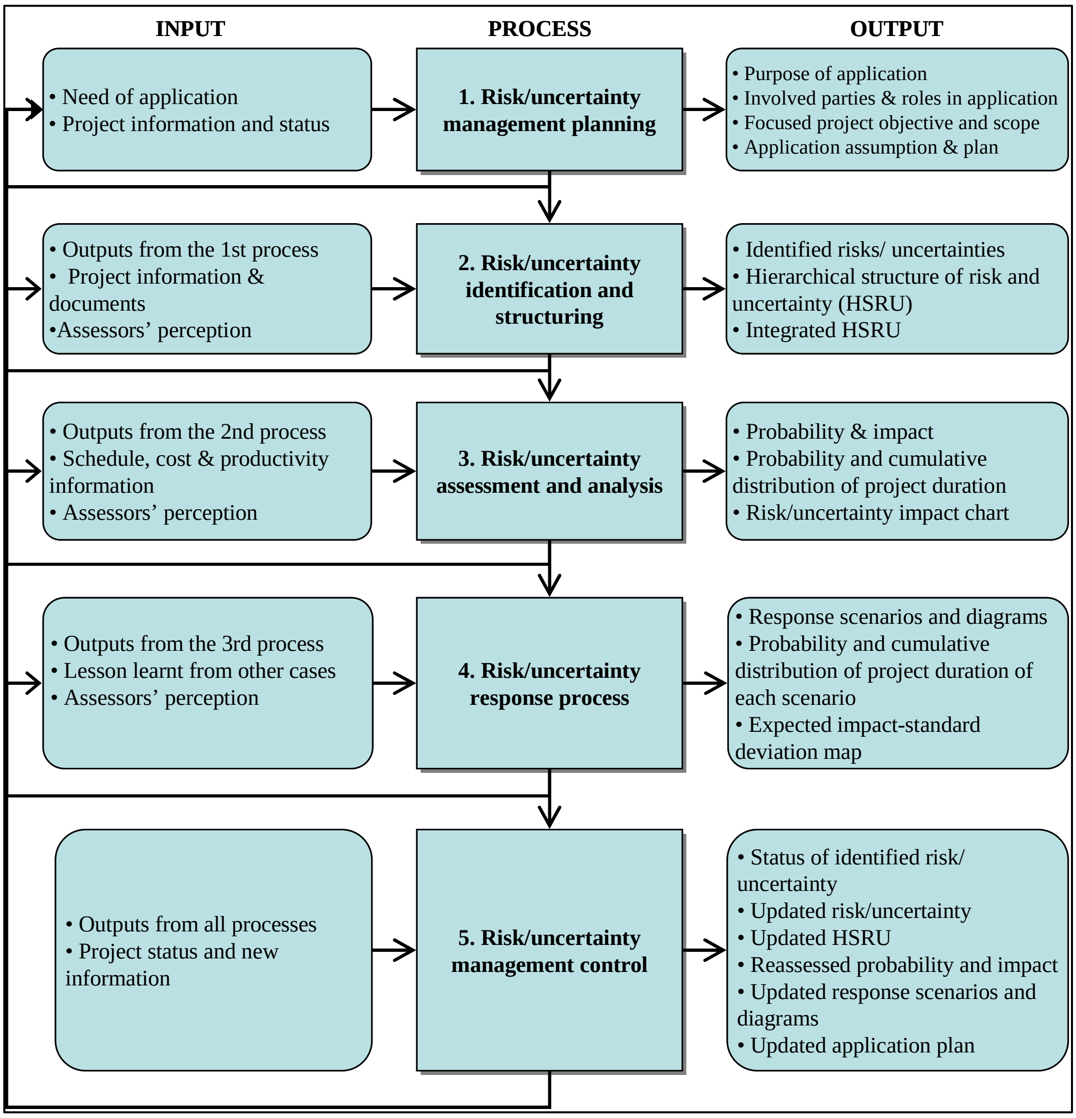

Figure 6 Input-process-output of MRUMP

For application, the MRUMP is provided in form of implementing manual describing necessary inputs, step-by-step procedure, and outputs of each process.

5. CONCLUSIONS

To overcome limitations of conventional RMPs, an effective risk and uncertainty management process called multi-party risk and uncertainty management process (MRUMP) has been developed. The MRUMP is a logical and systematic tool assisting all parties to systematically and efficiently manage risks and uncertainties. It integrates all parties' views in scope and processes and aims to assist practitioners e.g., policy maker, lender, owner, consultant, and contractor who involved with the project.

For better dealing with risks and uncertainties, the MRUMP provides: 1) risk/uncertainty map as 'knowledge base' of risk and uncertainty, 2) HSRU framework for producing higher precision output, 3) DVP for quantifying and presenting dimensional output, and 4) processes in integrating multiple parties' views. The risk/uncertainty map, HSRU framework, DVP as well as response process, application planning process, and application control process are assembled together and included in the MRUMP. A number of systematic procedures and tools such as RUBS and risk/uncertainty checklist are also included in the MRUMP.

The essences in development of the MRUMP comprise of: 1) better treatment of low-probability and high-impact event, 2) higher precision of analysis outputs, representation of analysis outputs in terms of dimensional value, and facilitation of problem solving by integrating multiple parties' views.

The MRUMP is expected to provide assistance in policy making, planning and problem preventing at early stage of project and problem preventing and solving at later stage of project. Moreover, it encourages parties to communicate each other, identify problem, and cooperatively solve the problem that increases possibility of project success.

Successive paper explains application of the MRUMP to a real infrastructure project as a case study as well as discusses its applicability.

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