KICEM Journal of Construction Engineering and Project Management
Online ISSN 2233-9582

www.jcepm.org
http://dx.doi.org/10.6106/JCEPM.2016.6.2.024

Scenario Planning and Risk Failure Mode Effect and Analysis (RFMEA) based Management

Prof. Virendra Kumar Paul[1] and Chaitali Basu[2]

Abstract - This paper elaborates the significance of scenario planning in risk management, and presents an integrated approach which takes into account the 'Risk Events' derived from scenario planning for risk prioritisation. This research integrates scenario planning with Risk Failure Mode and Effect Analysis (RFMEA) through examples from construction litigations of project schedule and cost overrun cases as a simplified approach to project risk management. The proposed methodology incorporates scenarios developed from realistic events of dispute and arbitration cases from construction projects, and thereby increasing potential to foresee risks and their effects well in advance. The results from this methodology shall be validated against outcome of survey study conducted by KPMG-PMI (2013) on project schedule and cost overruns that was based on Ministry of Statistics and Programme Implementation (MoSPI) Project Monitoring data for 2012-13.

Keyword: Scenario Planning, RFMEA, Risk Management, Detection Value, Risk Events

I. INTRODUCTION

1.1. Scenario and Scenario Planning

The dictionary definition holds scenario as "an outline of a natural or expected course of events", (Ratcliffe, 2000). Furthermore, scenario approach also involves development of future situations and also setting out paths that lead from the present situation to these future situations. In addition Scenarios lower the level of uncertainties, provide guidelines for decision making, and are alternative ways of thinking how organisations may operate under different sets of future possibilities (Ratcliffe, 2000). Coates (2000) states that a scenario tells a story for the possible or probable policy actions and outcomes, while Godet (1987) argues that scenarios encourage decision-makers to ponder upon a series of 'what-if' stories. Scenarios are purposeful stories about how a contextual environment can unfold in time for projects (van der Heijden et al. 2002).

The credit for originating scenario planning goes to American game theorist and futurist Herman Kahn but it is said that simultaneous form of its practice also emerged from France from the works of Gaston Berger, Bertrand de Jouvenel, and others (Kupers and Wilkinson, 2013). Scenario Planning has been most comprehensively used by Shell for more than 45 years, starting from 1970s, besides the Shell-style of scenario planning has not been oriented towards predicting the future but more on deriving vital linkages between organisation processes and has continued to evolve and help shape the company's global thinking and strategy (Kupers and Wilkinson, 2013).

Scenario planning consists of the three essential components (Daszyńska-Żygadło, 2012). First, identifying a scenario story consisting of definite future end where all combinations of uncertainties and emergent solutions find a final point in time, secondly, interpretation of relevant past and current events for creating scenarios, and thirdly, developing logics on how a particular scenario moves from the past to present to future. Therefore, a scenario will essentially elaborate the interplay of predetermined elements and resolved uncertainties. This process results in a complete description of examined factors that can impact a project. Moreover, scenario planning is an organisational social-reasoning process in which participants share their perceptions on logical conclusions to potential stories a project generates through the stages of scenario planning. From the perspective of risk management, scenario planning is a tool that organisations use to transform their learning capabilities into specifically planned responses that prepares the organisation to react to, and recover from exogenous shocks. As against dominant emphasis of literature on quantitative risk analysis, scenario planning is mainly qualitative assessment of real options (Miller and Waller, 2003). Thus, firms can develop a combination of scenarios of exogenous shocks, and then develop a list of actions of response for the risks. Scenario planning though being a well-established concept, however, it is incomplete as a tool for forecasting unless it is linked to the risk management for project management application. In this research, Scenario planning and risk management shall be discussed further as an integrated tool for creating an application of scenario based planning in construction project management.

II. RISK MANAGEMENT & RFMEA

2.1. Risk Management and RFMEA; Differences and Integration

The PMBoK 5th Edition (2013)[1] describes Project Risk as "an uncertain event or condition that, if it occurs, either has a positive or negative effect on one or more project objectives such as scope, schedule, cost, and

[1] Rose (2013) is editor/PMP Reviewer of PMBoK (Project Management Body of Knowledge) 5th Edition

[1] Professor of Building Engieering and Management, Department of Building Engineering and Management, School of Planning and Architecture, 6-B, IP Estate, New Delhi-110002 (India); e-mail: virendrakumarpaul@gmail.com vk.paul@spa.ac.in (*Corresponding Author)
[2] Assistant Professor, Department of Building Engineering and Management, School of Planning and Architecture, 6-B, IP Estate, New Delhi-110002 (India), e-mail: ar.chaitalibasu@gmail.com

quality". In addition, Project Risk has its origins in the uncertainty present in all projects, and can have single or multiple causes and impacts. Datta and Mukherjee (2001) state that "successful project completion depends to a great extent on the early identification of immediate risks." Among the tools available for risk management in project environment, majority of them revolve around risk identification, and the outcome is a risk register that lists risks which have already occurred in similar projects or are identification of critical success factors (Jiang et al, 2000, 2002; Jiang and Klien, 2001; Datta and Mukherjee, 2001; Royer, 2000; Gambôa). The process is based on brainstorming risks for each project phase wherein risk is assessed for its impact and a response plan is generated (Carbone and Tippett, 2004). Further, they state that this process is not effective for response planning as no option is available for risk prioritisation, hence immediate risk concerns can be overlooked.

Project Risk Failure Mode and Effect Analysis (RFMEA) is the modified approach to Failure Mode and Effect Analysis (FMEA) and is used to identify, quantify, and eliminate (or reduce) risks in project environment. It is defined as a 'detection technique' for risk events with sufficient time buffer for planning contingencies (Carbone and Tippett, 2004). Pritchard (2000) was the first to identify Failure Mode and Effects Analysis (FMEA) as an advanced technique capable of summarizing project risks. Carbone and Tippett (2004) extended the technique for risk priority planning, and termed it as RFMEA (or Risk FMEA). Standard FMEA evaluates failure mode for products and services based on three factors based on failure; occurrence, severity and detection (Chrysler Corp, Ford Motor Co., and General Motor Corp., 1995) while RFMEA the three factors get modified to be based on risk; Likelihood of risk occurring (how often has this occurred, and how valid for a project), Impact of risk (on its happening, what comes next, and how much does it affect a project), and Detection of risk (how early is it detected).

While, in FMEA, the Risk Score is the multiplication result of two factors, Likelihood and Impact, in RFMEA Risk Priority Number or RPN is the multiplication result of three factors; Likelihood, Impact, and Detection Value of Risks. In this formula, the major deviation of RFMEA from conventional FMEA is the reverse use of Detection Value. In FMEA if a risk cannot be detected then higher values are assigned to the same during initial risk planning. The Detection Value actually pertains to the ability of the team to foresee a risk event with as much contingency time as possible and the value lies in the process of discussion and brainstorming for risks events to better prepare for them. But, the Detection Value is solely on the discretion of the experts, and is of subjective in nature, hence prone to doubt. These numbers are highly dependent upon the people involved in the process, subject to behavioural attributes like either being a risk taker or being risk averse.

In order to increase the validity of FMEA in being more efficient, if scenario planning is overlapped with RFMEA, then comprehensive data collected from construction disputes and arbitration cases carried out by conducting literature study of the copies of arbitration judgements in construction projects will work to have a lower Detection Value because they are no longer uncertain. There can be instances in the project environment wherein teams are often unsure of detecting risks, and ranking them in for order of priority of remedial action. However, as the assignment of Detection Value is subjective, thus to strengthen the value, it can be related to scenarios which are specific risk events. Hence, once a basis for assigning Detection Value gets created from the scenario planning, the element of uncertainty in detection method of risk is eliminated. This stance is supported by Carbone and Tippett (2004) who state that a full contingency plan in first stages is not as efficient as adding a lower detecting capability which turns out to be cheaper than developing contingency plans in first step.

The aim of this research paper is to highlight the usefulness of scenario planning as a tool for risk management by defining a process which integrates scenarios into the framework of RFMEA quantitatively, and thereby increase the accuracy of risk identification and prioritisation; especially that of unknown risks either specific project-based and/or overlooked when scouring through generic risk registers. In addition, the process of scenario planning is based on actual case events, hence, the presumptive basis of scenario development gets circumvented, and eventually a database of both generic and project-specific risks is developed very similar to Risk Registers

The results of this study are validated from data collected in a study conducted by KPMG-PMI (2013)[2] on project schedule and cost overruns that was based on MoSPI Project Monitoring data for 2012 wherein, a portfolio of 25-public sector infrastructure projects of varying sizes under MoSPI monitoring were selected, and KPMG team conducted site visits and case studies to unearth the factors detrimental to project schedule and hence project cost. Further, the scenarios are created and risk is determined to validate the scenario prediction that has resulted in the litigation.

III. METHODOLOGY

3. Methodology

This study was conducted in 6 stages which are explained in Figure 1. Stages 1 to 3 are based on desk research on the identification of various causes of risk, development of scenarios, and linking the scenarios with identified causes. Stages 4-6 are the integration stages of scenarios with RFMEA, wherein the three risk factors; Likehood, Impact and Detection are ascertained to be ranked by experts. Eventually, RPN is calculated to rank the scenarios, thereby identifying the most certain risk a project would have faced. These stages also include the validation of the methodology, and results are compared

[2] Study on project schedule and cost overruns (2013). [2] KPMG-PMI (2013) full study is available on [http://www.pmi.org.in/manageindia/volume5/issue03/report.abstract.html]

with the results of previously undertaken study survey on project risks which is publically validated. Detailed description of the stages with steps follows herein.

3.1. Literature Study : Scenario Planning

In Stage 1, for the purpose of creating scenarios for construction projects, basically pertaining to time, cost or quality issues, a total of 9-randomly selected Dispute and Arbitration cases of Indian construction projects were appraised from data available in public domain for year 2013-14 [Available on http://indiankanoon.org/] [17]. These cases pertain to the litigation arising out of disputes on time and cost overrun in construction industry. These 9 cases were reviewed further to arrive at generic cases of time-cost overruns to build useful scenarios

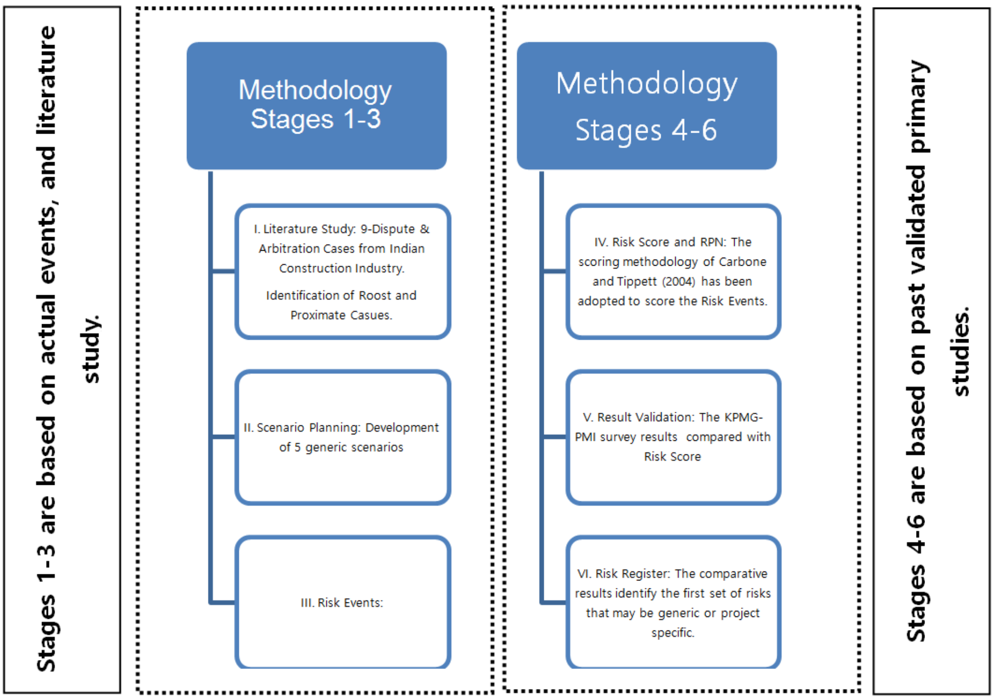

FIGURE I
Methodology Flow-Chart

Taking from the three components defined by Daszyńska-Żygadło (2012); definite future end, interpretation of relevant past and current events, and defining the flow from past to future, the cases are broken-down in 2-3 statements- what happened in the case, what it affected, and how it becomes a risk generic for future. In addition, Kumaraswamy (1997) has attempted to understand the causality[3] of disputes in the construction sector by determining the root cause which is the underlying reason hence if removed then problem will not reoccur, and the proximate cause which is the effect that immediately precedes the cause. Risk scenario statements were assigned between the root and proximate causes from his studies that involved developing a hierarchy claims, proximate and root causes from data collection and analysis of 46 responses to questionnaires in Hong Kong from 61 projects (Kumaraswamy, 1997). For a futuristic endeavour in developing risk registers, scenarios are assigned Risk IDs (a practise also prevalent in RFMEA). Case summary, their root and proximate causes are presented in Table 1. The divergence here is that instead of being futuristic events foretold, the events are predetermined from project-specific cases to more generic all-encompassing project environment situations.

3.2.. Risk Events

Disputes are often cited as being endemic feature of the Indian construction industry (Sinha and Wayal, 2008), plagued by combined effect of complex projects and ambiguities in the contract form and complex nature of execution of contracts (Iyer et al, 2007) eventually cause adversarial impacts such as increase in number and frequency of claims and disputes besides time and cost overruns. Risk Events are such adversarial impacts, and developed from Carbone and Tippett (2004) study. Risk Events has three components; Likelihood (how often has this occurred, and how is it valid for a project), Impact (on its happening, what comes next, and how much does it affect a project), Detection Value (how early is it detected).

3.3. Risk Score and Risk Priority Number

The stage 4 is assigning of values as per value guidance by Carbone and Tippett (2004) and of Likelihood, Impact and Detection values. The scoring is on a scale of 1-10 for Likehood and Impact, while 1-4 for Detection (1

[3] Causality is the relation between an event (cause), and a second event (effect).

being lowest and 4/10 being highest). Likehood is scored as per the symptoms a project is suffering from, Impact is scored on basis of how the symptoms effect on project's schedule, corresponding cost, and technical resources, while Detection is scored on how early the risk gets identified. The major deviation introduced in this research is technically lowering the Detection score range between 1-4, as scenarios integration lowers uncertainty. The RPN (Risk Priority Number) in RFMEA is the multiplication result of three factors; Likelihood, Impact, and Detection values of Risk Events. The results are highlighted in Table 2.

TABLE I
Combined Methodology Stages 1-3

Risk ID	**Scenario**
1.1	The Owner/Client hands-over the construction site to contractor in piecemeal and not complete unencumbered possession. The Contractor thereby faces delay in commencement of project, and suffers monetary loss due to idling equipment and manpower.
Root Cause	Delay in Land Acquisition. Delay in decision making. Unfair risk allocation.
Proximate Cause	Compensation to contractor for idling resources due to delays, De/Remobilization charges for carrying out delayed work.
1.2	The Contractor has to source material of a certain make/specification only that causes extra lead (time), and cost of procurement which had not been considered in contract document. The Contractor realizes that he could incur an additional expense for procurement, and also might face delay in obtaining the material, and decides to contest the Contract.
Root Cause	Lack of information. Unrealistic information expectations. Contractual problems. Opportunistic behaviour.
Proximate Cause	Reluctance of parties to accept responsibility for change, different interpretation of contract clauses, or failure of contract to cover an unexpected event.
1.3	The Contractor incorrectly interprets the Adjustment Formulae-pn contractual clause (a price adjustment factor to be applied to the amount for payment of the work carried out in the subject month determined where variations and day work are not otherwise subject to adjustment) and assumes it as price adjustment for entire work. Hence, he decides to contest rate escalation based on this clause, and thereby delays the project.
Root Cause	Inappropriate contract form. Inadequate contract administration. Inappropriate contractor selection.
Proximate Cause	Rework costs, omissions errors and construction changes.
1.4	The Owner/Client, and his team delay in granting clearance to construction drawings, work programs, and work instructions. In addition, there are frequent errors, omissions and changes in drawings, subsequently resulting in recurrent delays. The Contractor feels that due to constant delays, he would be unable to continue work on prevailing contract rates, and decides to contest the same, causing further delay to project.
Root Cause	Client inexperience. Failure to undertake design audits, verifications and reviews of the documents prior to construction.
Proximate Cause	Reimbursement of variation and escalation due to extended stay, extension of time for delays, compensation for loss of overheads and profits, for extra expenditure incurred on overheads, establishment and other supervisory expenditure due to extended stay.
1.5	The project is constantly plagued by politically motivated problems/disturbance/agitation, created by people living around the site, stoppage of work by locals, and onset of public 'bandhs/strikes', causing constant delays, the risk of which cannot be fully attributed to either client or contractor.
Root Cause	The prevailing socio-economic environment of the project site.
Proximate Cause	Delay is completion of project, escalation in rates, termination of project, and loss of reputation.

TABLE II
Risk Scoring and RPN

ID	Likelihood	Impact	Detection	RPN
1.1	Project has acquired unencumbered land.	Delay; time extension Claim of liquidated damage; no probable dispute if settled internally.	Risk event pre-determined.	128
Risk Rank	8	8	2	
1.2	There can be delay in handing over due to decision making at higher level.	Compensatory clause is owner-centric, possible dispute	Risk event pertaining to decision making to be evaluated.	168
Risk Rank	8	7	3	
	Delay due to inaccurate/incomplete contractual conditions leading to misinterpretation.	Delay, dispute certain.	Risk event pertaining to opportunistic behaviour to be avoided.	192
Risk Rank	8	8	3	
1.3	Lack of general clarity on 'Formulae-pn', price adjustment factor.	Delay, possible dispute but claimant may not be awarded rate escalation.	Risk event pertaining to time delay and quality of work (poor quality post arbitration outcome).	75
Risk Rank	5	5	3	
1.4	Lack of quality audits at client/design end.	Recurrent delays, reworks.	Risk event pertaining to poor work quality, can be pre-determined.	
Risk Rank	6	4	2	48
1.5	Socio-economic factors disrupting work progress.	Delay; time extension Claim of liquidated damage, no probable dispute if settled internally.	Risk event pertaining to feasibility studies, can be pre-determined.	
Risk Rank	7	8	2	112

*Risk Ranking is based on researchers' observation of case studies.

3.4 RPN Validation

In 2013, KPMG-PMI (Project Management Institute) conducted a survey based on Project Monitoring Data by MoSPI (Ministry of Statistics and Programme Implementation) on project schedule and cost overruns and identified factors which plague the Indian construction industry causing delays and subsequent disputes. For this study, the five factors which closely related to Risk Events, and the percentage of respondents who strongly agreed/agreed with them was extracted. Table 3 compares the points of corroboration and conflicts.

TABLE III
RPN Comparison with KPMG-PMI (2013) Survey Results

Risk Event ID	KPMG-PMI (2013) schedule and cost overrun factors	Strongly Agree	Rank	RPN	Rank
1.1	Land/site handover	39%	2	128	3
1.2	Delay in decision making	38%	3	168	2
1.3	Design/scope change	79%	1	192	1
1.4	Contractual disputes	7%	5	75	5
1.5	Material price escalations	26%	4	48	6
1.6	Geographical challenges and cultural differences	3%	6	112	4

IV. RESULTS AND DISCUSSION

4.1. Results and Discussion

The comparison of factors of this research and from outcome of previous study undertaken highlights that Design /scope change is considered the most important factor for schedule delay and subsequent cost overrun. Similarly, contractual disputes are equally ranked at 5th position. The major point of deviation is in the rankings of material price escalations and geographical challenges and cultural difference. This difference stems from the basic understanding of the factors in the study and the dispute-arbitration case studies. While the survey deciphers material escalation as volatility in material prices, the case studies point to the fact how this volatility is adjusted in contract by employer and interpreted by contractor, and the ensuing confusions from the adjustment factors/formulae. The next point of deflection is on the geographical challenges and cultural differences, and while the survey has reflected upon it in a more generic light, the case studies and scenarios have gone in depth to understand project-level situations. Thus, a natural deviant in scoring has occurred. However, given the validation, it can be seen that scenarios are credible methods of bringing forth very minute level risks which though touched upon broadly, gets definitive form through storyboarding.

V. CONCLUSION

5.1. Conclusion

The purpose of this study was to augment RFMEA in being more efficient tool for risk management by overlapping with scenario planning for which data was collected from construction disputes and arbitration cases carried out by conducting literature study of the copies of arbitration judgements in construction projects. Hence, the element of uncertainty in detection method of risk is eliminated by using scenario planning. This stance is supported by Carbone and Tippett (2004) who state that a full contingency plan in first stages is not as efficient as adding a lower detecting capability for risks which also turns out to be cheaper option than developing contingency plans. Moreover, this research is supported by the validation from KPMG-PMI (2013) survey results that show comparable results but achieved in much lesser time-span. Overall, the advantage is scenario planning through reference to actual events considerably improves the effectiveness of risk detection, and risk can now be identified within adequate timeframe for action, and the time-schedule for identifying the risks reduce considerably. Further, this reduces team frustration and time wastage over detecting each and every risk rather than concentrating on risk impacts.

However, it is recommended that further research is needed in this area to develop risk registers from this method that can be made universally available for construction projects. Also, risk events and RPN have to be developed and undertaken as survey studies which experts in the field of construction can score upon, thus establishing the scoring criteria, and supporting the integrated RFMEA-Scenario Planning framework as an innovative confirmed risk management tool.

REFERENCES

[1] Carbone, T. A., & Tippett, D. D. (2004). Project risk management using the project risk FMEA. *Engineering Management Journal*, *16*(4), 28-35.

[2] Chrysler Corporation, Ford Motor Company, General Motors Corporation (1995), “Potential failure mode and effects analysis”, Reference Manual, 2nd ed.

[3] Coates, F.J. (2000): Scenario Planning, in: Technological Forecasting and Social Change 65, 115-123.

[4] Daszyńska-Żygadło, K. (2012). Scenario planning and real options analysis in integrated risk management process. Universitatis Mariae Curie-Skłodowska. Sectio H. Oeconomia, 46(4 (XLVI)), 75-84.

[5] Datta, S, and Mukerjee, S.K (2001) “Developing a Risk Management Matrix for Effective Project Planning—An Empirical Study,” *Project Management Journal*, 32:2, pp. 45–57.

[6] Godet, M. (1987) Scenarios and Strategic Management, Butterworth, London.

[7] Iyer, K.C, Chaphalkar, N.B, Joshi, G.A (2007), “Understanding Time Delay Disputes in Construction Contracts,” International Journal of Project Management 26, pp. 174-184.

[8] Kumaraswamy, M. (1997), “Conflicts, claims and disputes”, Engineering, *Construction and Architectural Management*, Vol. 4 No. 2, pp. 95-111.

[9] Kupers, R and Wilkinson, A (2013). Living in the Futures. Harvard Business Review. Available online [https://hbr.org/2013/05/living-in-the-futures].

[10] KPMG-PMI (2013). Study on project schedule and cost overruns. Available online [http://www.pmi.org.in/manageindia/volume5/issue03/report.abstract.html].

[11] Pritchard, Carl L. (2000). "Advanced Risk—How Big is Your Crystal Ball?" Proceedings Project Management Institute Annual Seminars & Symposium.

[12] Ratcliffe, J. (2000): Scenario building: a suitable method for strategic property planning?. Property Management, Vol. 18 Iss: 2, pp.127-144.

[13] Rose, K. H. (2013). A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition. *Project Management Journal*, *44*(3), e1-e1.

[14] Sawhney, A , Agnihotri , R, Paul , VK (2014) "Grand challenges for the Indian construction industry", *Built Environment Project and Asset Management*, Vol. 4 Iss: 4, pp.317 – 334.

[15] Sinha, M, Wayal, A.S (2008). "Dispute Causation in Construction Projects". *IOSR Journal of Mechanical and Civil Engineering, (IOSR-JMCE) ISSN*: 2278-1684, pp. 54-58.

[16] van der Heijden, K. (2002) 'Can internally generated futures accelerate organizational learning?', Paper for Conference on Probing the Future: Developing Organizational Foresight in the Knowledge Economy, Strathclyde University, UK.

[17] List of Dispute and Arbitration Cases from http://indiankanoon.org/[Accesed on 15th Dec 2014]

1. http://indiankanoon.org/doc/158014472/
2. http://indiankanoon.org/doc/173600971/
3. http://indiankanoon.org/doc/142262332/
4. http://indiankanoon.org/doc/177830522/
5. http://indiankanoon.org/doc/139938493/
6. http://indiankanoon.org/doc/161758924/
7. http://indiankanoon.org/doc/145890018/
8. http://indiankanoon.org/doc/9741462/
9. http://indiankanoon.org/doc/194276058/