Eng Int Syst (2023) 6: 439–448

Engineering
Intelligent Systems

House of Benefits and Fuzzy Consensus for Multi-Stakeholder Consensus in PPP

Elizabeth Chang[1], Amit Ghildyal[2], Ru. D. Perera[1], Md. Saiful Islam[1] and Achim Karduck[3]

[1] *Griffith University, Australia*
[2] *NNSO, Department of Defence, Australia*
[3] *Furtwangen University, Germany*

There has been increasing adoption of a Benefit Approach to mega project management including PPP (Project, Program, and Portfolio) in the government sector and large business particularly in the areas of procurement, commercial grade contracts, IT governance, and the innovation investment space. Intangible benefits and unclassified indirect achievable and unquantifiable tangible benefits constitute around 80% of project benefits laid out in procurement contracts. Mega projects or complex contracts involve multiple stakeholders, and each of whom has to be in agreement across the range of benefits. To provide commonly agreed and clarity in understanding different aspects of tangible and intangible benefits, in this paper, we present a House of Benefits (HoB) , which is a visual representation with clear illustration of the Benefit between the stakeholders and their consensus on the agreed Project, Program or Portfolio Benefits. It is important to recognize the vagueness, fuzzy, evolving, and dynamic nature of these benefits which motivate the study of the definition, measurement, monitoring and evaluation of these benefits. We have developed a fuzzy systems-based characterization of these benefits which allows us to address these issues. It also helps to recognize the fact that PPP requires assessment of benefits at the Portfolio, Program and Project levels which are coherent with each other. We have developed a stratified fuzzy systems-based approach to address this. The House of Benefits is a tool that utilizes a Fuzzy Consensus approach to provide a theoretically underpinning consensus technique for reaching a group decision support to quantify the achievable benefits, determine consensus on the agreed, achievable, tangible and intangible benefits, and measurement metrics so that this is accepted among the different stakeholders. The House of Benefits, as a tool, will support the measurability and quantification of achievable benefits in a dynamic business and operational environment, enablement of new and emerging benefit identification and helps provide a systematic approach to avoid lack of accountability or governance failure for mega projects.

Keywords: House of Benefits, Benefit Realisation, Social Fuzzy Consensus, Group Decision Support Systems, Project Management

1. INTRODUCTION

PPP-Project, program & portfolio (PPP) levels of project management are regarded as the foundations for setting up government or business enterprise performance measures for project procurement, contracting, delivery, deployment and benefit. Only two percent of digital transformation projects in Government and big business succeed. (CIO group 2022). Our recent field studies and practical evaluation of benefit approaches in Program, Portfolio and Project (PPP) showed that tangible benefits that can be identified and measured in PPP management such as cost saving, Return on Investment constitute about 20 percent of benefits specified in contracts and approximately 80% of benefits are Intangible benefits, such as capability, efficiency etc. The benefits (Tangible and Intangible) are largely identified in the context of strategic intent, social economic drivers,

Manuscript submitted to ACM

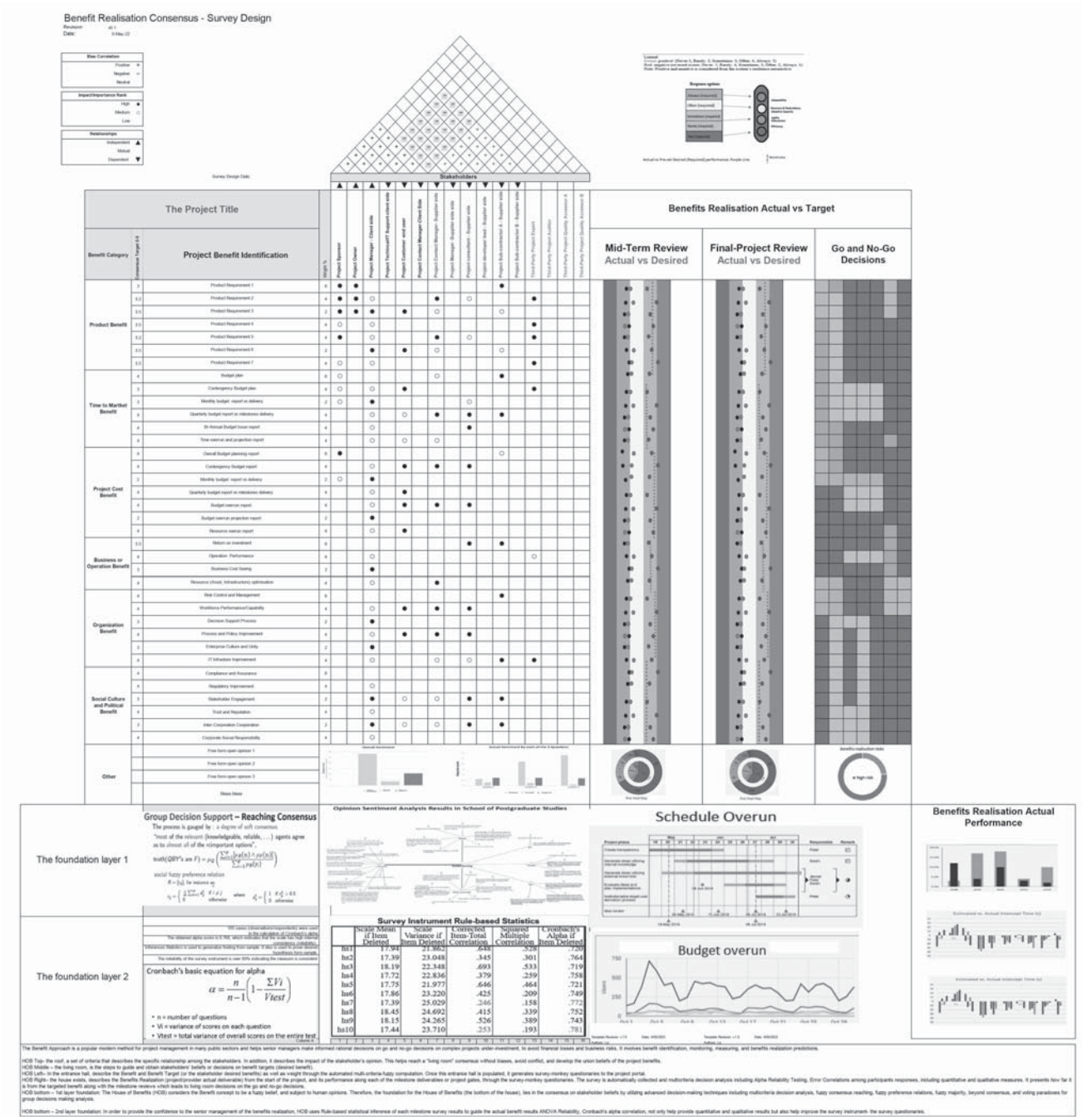


Figure 1 House of Benefits – A tool to ascertain common consensus by stakeholders on project benefits realisation.

industrial inventive steps or futuristics. The vagueness and imprecision of benefit concepts, particularly intangible benefits, has resulted in no solid measurement techniques and tools available to support the Benefits Approach to PPP to help realize the benefits, resulting in repeated high cost in procurement, contracts, IT and investment. Understanding the importance of "what gets measured gets delivered" and recognizing the vagueness, fuzzy, evolving and dynamic nature of the intangible benefits, our previous work developed a fuzzy systems based characterization of these benefits which permitted measurement, monitoring and evaluation of them [9]. In [8], we explored a consensus based approach to benefits realization in project management. In this paper, we develop a visual representation to create a clearer understanding of the benefits for the different stakeholders using the House of benefits.

2. THE HOUSE OF BENEFITS REALIZATION FOR PPP

The HoB (House of Benefits) is a practical approach and a tool to ascertain common consensus by stakeholders towards the realization of project benefits (Figure 1). The aggregate consensus after considering individual benefit measurement can be attained at the project level. In the project management discipline, this is a grounded approach moving from traditional management practices towards today's needs

of novel IT projects and related benefits management. The rationale of HoB is to incorporate a balanced method to provide a visual representation in project management benefits and their relationship to stakeholders. to provide clarity of understanding. Our major benefit management phases are Benefit identification, monitoring, measuring, and Benefit realization predictions. The benefit categories are 'product benefit', 'time to market', 'project cost benefit', 'business or operation benefit', 'organization benefit', and 'socio-cultural and political benefit'. The foundation of the model explains the layer 01 of Group decision support and reaching consensus and the layer 02 of Cronbach basic equation for alpha.

The House of Benefits Realization is an approach and a tool to support project or PPP management in public sectors or mega industries and helps senior managers make informed rational decisions for go and no-go decisions on complex projects under-investment, to avoid financial losses and business risks. It captures the four phases of benefit management namely benefit identification, monitoring, measuring, and benefits realization predictions.

- **HoB Top** - The roof has a set of criteria that describe the specific relationship among the stakeholders. In addition, it describes the impact of the stakeholders' opinion. This helps reach a "living room" consensus without biases, while avoiding conflict, and developing the united belief of the project benefits.
- **HoB Middle** - The living room, illustrates the steps to guide and obtain stakeholders' beliefs or decisions on benefit targets (desired benefit).
- **HoB Left** - In the entrance hall, a description is provided of the Benefit and Benefit Target (or the stakeholders' desired benefits) as well as the weight used through the automated multi-criteria-fuzzy computation. Once this entrance hall is populated, it generates survey-monkey questionnaires for the project portal.
- **HoB Right** - The house exists, describes the Benefits Realization (project/provider actual deliverable) from the start of the project, and its performance along each of the milestone deliverables or project gates, through the survey-monkey questionnaires. The survey is automatically collected and multicriteria decision analysis including Alpha Reliability Testing, Error Correlations among participants' responses, including quantitative and qualitative measures. It presents how far it is from the targeted benefit along with the milestone reviews which leads to the living room decisions for go and no-go decisions.
- **HoB bottom** - First layer foundation: The House of Benefits (HoB) considers the benefit concept to be a fuzzy belief, and subject to human opinions. Therefore, the foundation for the House of Benefits (the bottom of the house), lies in the consensus on stakeholder beliefs by utilizing advanced decision-making techniques including multicriteria decision analysis, fuzzy consensus reaching, fuzzy preference relations, fuzzy majority, beyond consensus, and voting paradoxes for group decisions making analysis.
- **HoB bottom** - Second layer foundation: It is designed to provide confidence to senior management of the benefits realization, HoB uses rule-based statistical inference for each milestone survey results to guide the actual benefit results ANOVA Reliability, Cronbach's alpha correlation, to not only help provide quantitative and qualitative results but to also help improve the survey instrument – the survey questionnaires.

The following sections describe the methods used to determine fuzzy benefit realization, fuzzy stratification and fuzzy consensus for group decision support which are used to determine the value of different variables in the HoB.

3. THE NEED FOR BENEFITS REALIZATION APPROACH

A Project is a macro-level organizational asset aligning to the broader perspectives of the organizational objective(s) [15]. Programs constitute a well-coordinated, logically combined collection of related and/or non-related organizational projects which help achieve organizational objectives [11], [2], [1]. A portfolio is a collection of discipline-based operations that subdivide the Enterprise or the Organization into groups for ease of hierarchical management, often named divisions, departments, or faculties, and it usually operates and runs several parallel programs. Generally the performance of the portfolio is based on its programs' performance. Therefore, in terms of benefit identification in PPP, the benefits are transferable to the upper layers of the PPP, where benefit in PPP is the composite of the projects' and programs' benefits and must align with the Organization's or Enterprise's objectives or goals. Therefore, the benefits must be designated for each level of PPP and their linkage with the benefits at other levels determined and specified. To address this, we developed and utilized an extension of the techniques for the stratified fuzzy systems-based approach [10]. Both approaches rely on expert opinions. However, we note that these experts are only one group of stakeholders and other groups of stakeholders such as suppliers, clients, managers and so forth, must be considered in addition to the experts. In an initial attempt to address this, an approach to benefits realization based on the fuzzy consensus approach was developed [8]. This discussion sets out the many dimensional nature of the benefits approach when applied to PPP, sometimes making difficult the comprehension of the different parts within the whole. This has motivated the work of this paper to provide a readily comprehensible representation whose visual presentation, based on the new concept of house of benefits, makes it possible for all stakeholders to understand the different benefits and their linkages in the Benefit Approach to Project Management and PPP. This also considers the fuzzy consensus approach to support group decision making.

Benefits appear to be seemingly easy to understand at a senior or executive level for analyzing project performance because the projects encompass a wide aspect of the organization's performance. Organizations or government enterprises have tried to use measurement scales to quantify

the benefits on their projects in terms of return on investment. This has led to an upsurge of studies on the benefit approach to project management including PPP, addressing not only tangible benefits but also intangible benefits. 'benefits' in the context of project management has been defined as the flow of value in terms of profit, HR cost, time saving in process automation, financial return, stakeholder engagement, project outcome (product), customer satisfaction rate, and many other facets among the collection of benefits [1], [15]. 'Tangible Benefits' are the benefits that can be translated into transaction cost or economic value in terms of time, physical resources, and human effort at scale. These benefits are quantifiable with probabilities and usually lead to significant improvement for an enterprise and are good projects for the organization to have because they are measurable, transparent, and result in resource optimization. 'Intangible Benefits' may be strategically focused benefits or emerging benefits that are auxiliary and are expected to be realized at the post-stage of the project management lifecycle. They are usually laid out as part of the Project Proposals, Business Plan, or Investment Contract. When the project is in its procurement stage, or the development stage, or at the project life cycle from its infancy to maturity, the benefit identification and realization continues to evolve. Due to the lack of methodologies and tools, these benefits are cumbersome to measure, to realize, and to communicate to customers. We believe Intangible Benefits may be partially achievable, subject to stakeholders' perception such as management authorization, or some end-user feedback, customer satisfaction, or employee engagement. In our qualitative interviews with many industry consultants for PPP, we found that they appreciate the concept of the benefits approach but do not have real tools to help measure and understand the realization of the intangible benefits. The benefits management process is comprised of fundamental stages which are classified logically, sequentially and entail connectedness to include benefit identification, benefit realization planning, benefit monitoring, and benefit realization [15]. Some researchers presented the approach from the benefit practitioner viewpoint, but here the benefit management is conducted at the post-mortem stage of the project with project benefit measurement. benefit measures are the key issues in many big business and public sector Project Procurements, as well as across the project lifecycle which are aimed to achieve benefit realization. Whilst measures for Tangible benefits are quantifiable and calculable and therefore measurable, the measurement of intangible benefits is more problematical. Nevertheless, the long-term effects of the measurement of project contract success with intangible benefits and the delivery of value to the organization is a silent area except for our work [9]. Furthermore, no work has been done on the measurement of intangible benefits that exist from projects, programs, and portfolio management except for the work in [10]. We believe that intangibility is a concept that can be successfully fathomed and understood only if the benefits are embedded in the quantitative approaches. The need for measurement approaches helps both project providers and users to understand whether they are realized. Intangible benefits may be partially achievable through balance between subjective and objective measures as well as balanced decision making between rational and irrational decisions. Therefore, it is critical to have a sound mechanism to evaluate and monitor the intangible benefits which lead to benefit realization.

4. BENEFITS IDENTIFICATION THROUGH FUZZY REPRESENTATION AND STRATIFICATION

The fuzzy approach in measuring benefits at the PPP levels namely, project, portfolio and program, in the overarching element the 'enterprise', is premised on Zadeh's formalism [14] together with later developments of Deshpande and Zwikael. The results in fuzzy techniques are promulgated to measure the benefits at the various tiers of the organization including project levels. There are two distinct challenges. First, the framework used to measure benefits at different levels of the project and, second, realizing the benefits. It can be argued that effectiveness, efficiency, responsiveness, compliance, and interoperability are intangible yet measurable benefits [14]. The portfolio components (PC) are classified as PC variables "PCvIJ", "PCvDJ" and "PCvPJ" which are related to the measurement and realization of PPP. The realization of the benefit 'stakeholder justice' can be visualized at the three PPP levels of the enterprise. Even though PPP benefits are managed independently by skills of benefit managers of the tiers, the overall benefit is aligned with the broader vision of the organization and the project. The different project-levels need a synergistic, systematic approach to harmonize the desired agreed, stated, target benefit as collectively shared project outcomes. The PPP benefits at the tiers are interrelated building on the fundamental fuzzy works of Zadeh [12–14], Kacpryzk and Fedrizzi [4, 6, 7], and Nurmi [3] that expound intuitive ideas to the calculation approach of the holistic benefit. The benefit realization is not equal and equitably observed at the different project levels and tiers. The reason is the intangibility of the project outcomes that result in varied benefit perceptions. In e-governance projects associated with public enterprise, the beneficiary majorly interacts with the portfolio-level that concerns the hierarchical, divisions or functional aspects of the benefit [1], [15]. However, the benefit is a 'holistic or balanced project outcome' with a contributory affect on the organizational objective. To realize stakeholder justice, we consider the twining pairs of project portfolio benefit options, leading to the following rules.

- **Rule 1:** PC_{VIJ} is low & PC_{VDJ} is high, THEN the contribution to benefit realization is sometimes
- **Rule 2:** PC_{VIJ} is low & PC_{VDJ} is medium, THEN the contribution to benefit realization is seldom
- **Rule 3:** PC_{VIJ} is low & PC_{VDJ} is low, THEN the contribution to benefit realization is never
- **Rule 4:** PC_{VIJ} is medium & PC_{VDJ} is high, THEN the contribution to benefit realization is on most occasions
- **Rule 5:** PC_{VIJ} is medium & PC_{VDJ} is medium, THEN the contribution to benefit realization is sometimes

- **Rule 6:** PC_{VIJ} is medium & PC_{VDJ} is low, THEN the contribution to benefit realization is seldom
- **Rule 7:** PC_{VIJ} is high & PC_{VDJ} is high, THEN the contribution to benefit realization is high
- **Rule 8:** PC_{VIJ} is high & PC_{VDJ} is medium, THEN the contribution to benefit realization is on most occasions
- **Rule 9:** PC_{VIJ} is high & PC_{VDJ} is low, THEN the contribution to benefit realization is sometimes

The nine (09) fuzzy control preference rules and five (05) benefit realization levels of 'high', 'on most occasions', 'sometimes', 'seldom' and 'never' are captured at the portfolio levels. As the PPP process of benefit realization is running on a thread amidst the three different levels of project, program, and portfolio it is practical to use a similar analogous approach to measure the program and project level benefits underscored by the mathematical calculations [15], [14]. However, the stakeholder justice at portfolio and program levels are interpreted in different ways as the decision makers, project leaders, and project beneficiaries observe it differently. Hence, a broader value and application is captured in the hierarchical higher order levels of the organizational project with more focus on the overarching, umbrella, wide project objectives such as innovation, creativity, and project success through e-governance. Therefore, probability theory and possibility theory [13, 14] provide formalisms with a dichotomous focus. In both approaches, the values $\tilde{A}$ come from measurements that are quantified or expert estimates that are like-quantified; quasi quantified, yet uncertain, fuzziness, subjective and ambiguous. In social consensus fuzzy algorithms that directly relates to expert estimates, in this case, we can presume the available values $((\tilde{A}))$ are different to actual values (unknown value, 'A') of the corresponding variable (PC_v). As a result, if the fuzzy preference relation $y = f\{x_1, \ldots, x_n\}$ for the actual value is exact; the resulting estimate value $\tilde{y} = f\{\widetilde{x_1}, \ldots, \widetilde{x_n}\}$ for y is different from actual value of y for the quantity of interest.

Any approach to measurement of benefits should be able to measure benefits at each of these different PPP levels as well as recognize the linkages expressing the alignment between the levels allowing coherent translation of the effects of benefit measurement from one level to the next. We decided to use a Fuzzy Stratified Methodology for measurement of benefits to address this. Stratification allows benefits to be defined in accordance with enterprise-wide objectives and measurable goals (horizontal) that include portfolios, programs and projects whilst considering deliverables at all levels of granulation, simplifying the development of measurement for benefit management and realization. Examples of stratification across the three levels are discussed in Ruwanthi D. et al. [10] and a summary is given next. **Stratification Level 1:** Enterprise benefits can be stratified along the Strategic Objectives, Vision or Mission Statements. The practical examples show the level 1 stratification process of a public enterprise along the strategic objectives according to its operations including Products, Services, Competencies and Future capabilities. **Stratification Level 2:** An Enterprise can be stratified by Domains (vertical) and Models (Horizontal) for Portfolio, Programs and Projects, to be analyzed for elements including time, space, budget, human resources, and enterprise reputation, with stratum in multiple two-dimensional views. While developing the firm foundation, stratification helps to define and classify benefits. This takes into account the enterprise-wide business objectives and balanced interests of division/portfolio/program/project competitive advantages, business values, enterprise performance, operations, change management, risk mitigation, strategic match, external outsourcing, products and services among others. **Stratification 3** 3 refers the stratification level associated with the project level.The alignment of the Objectives at the different stratification levels with PC House of Benefits and Fuzzy Consensus for Multi-Stakeholder Consensus in PPP variables is illustrated in (Table 3[10]). There are 12 benefits and 12 Pc variables. The benefits and the related objectives Enterprise level-Ob 1–3) Portfolio Level; (Ob 4–5), Program level (Ob 6–8), Project Level (Ob 9–12).

At the enterprise and Portfolio level, the financial goals of the government (or enterprise) have an impact on three strategic objectives, namely, innovation (Ob1), enterprise performance (Ob2) and digital strategy (Ob3). The cost/savings (PC variable) for the government (or enterprise) is influenced by enterprise performance (Ob2), digital strategy (Ob3) and clear accountability (Ob4). The proft/loss variable has a relationship with enterprise performance (Ob2) and digital strategy (Ob3). The other variables' performance is affected by innovation (Ob1), enterprise performance (Ob2), and standardized business operations (Ob5). Enterprise performance (Ob2) and standardized business operations (Ob5) are influenced by time benefit. Human resources are influenced by enterprise performance (Ob 2) and digital strategy (Ob 3). The next step after benefit identification is measuring the benefits. benefits performance measures and benefits acceptance testing is a critical requirement for benefits realization.

5. BENEFIT MEASURES FOR BENEFIT REALIZATION

The linguistic term 'project benefit realization' can be expressed in linguistic hedges such as Very High, High, Moderate, Poor and Very Poor. Total benefit realization is based on the 5 categories which are dependent on 12 PC (Project Components) variables. Figure 2 portrays the Hierarchical Structure of Project benefit Realization.

Beliefs are computed for all the experts. When the distance between plausibility and belief is minimum for the decision parameter such as very high benefit realization, high benefit realization and so on, then the decision is acceptable by that expert. The exercise needs to be carried out for all the experts. The final decision will be based on maximum principle. The parameter which occurs the maximum number of times will be considered, for example the Project benefit highly realized. It is possible to rank the output based on belief plausibility proposed in the Dempster Shafer Theory. Strategically managed information is the critical success factor of the public sector across the different portfolios.

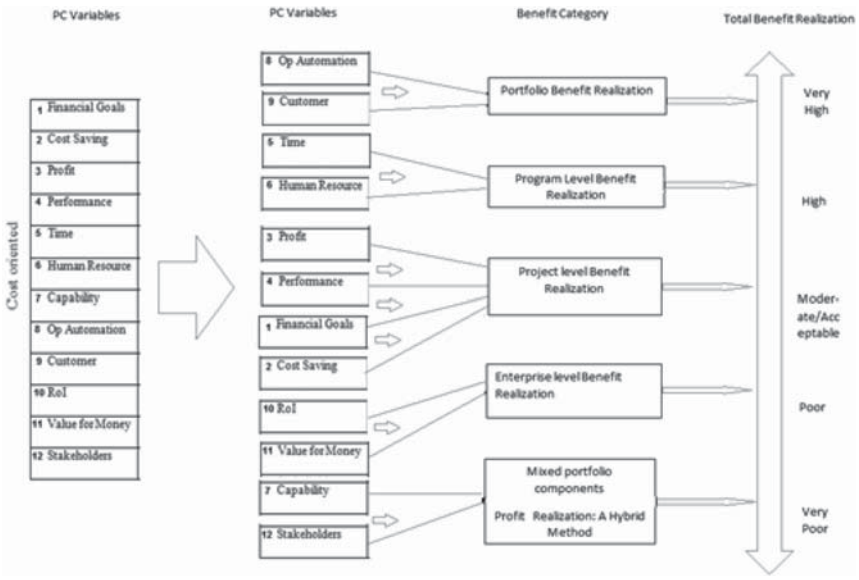


Figure 2 From Benefit Identification to Benefit Realization in PPP management.

Using majority voting algorithm, we find that most experts believe that operation automation has an 'increasing' relation with benefit realization.

6. THE PROJECT EXAMPLE WITH FUZZY CONSENSUS FOR MULTIPLE STAKEHOLDER DECISION MAKING IN PPP BENEFITS

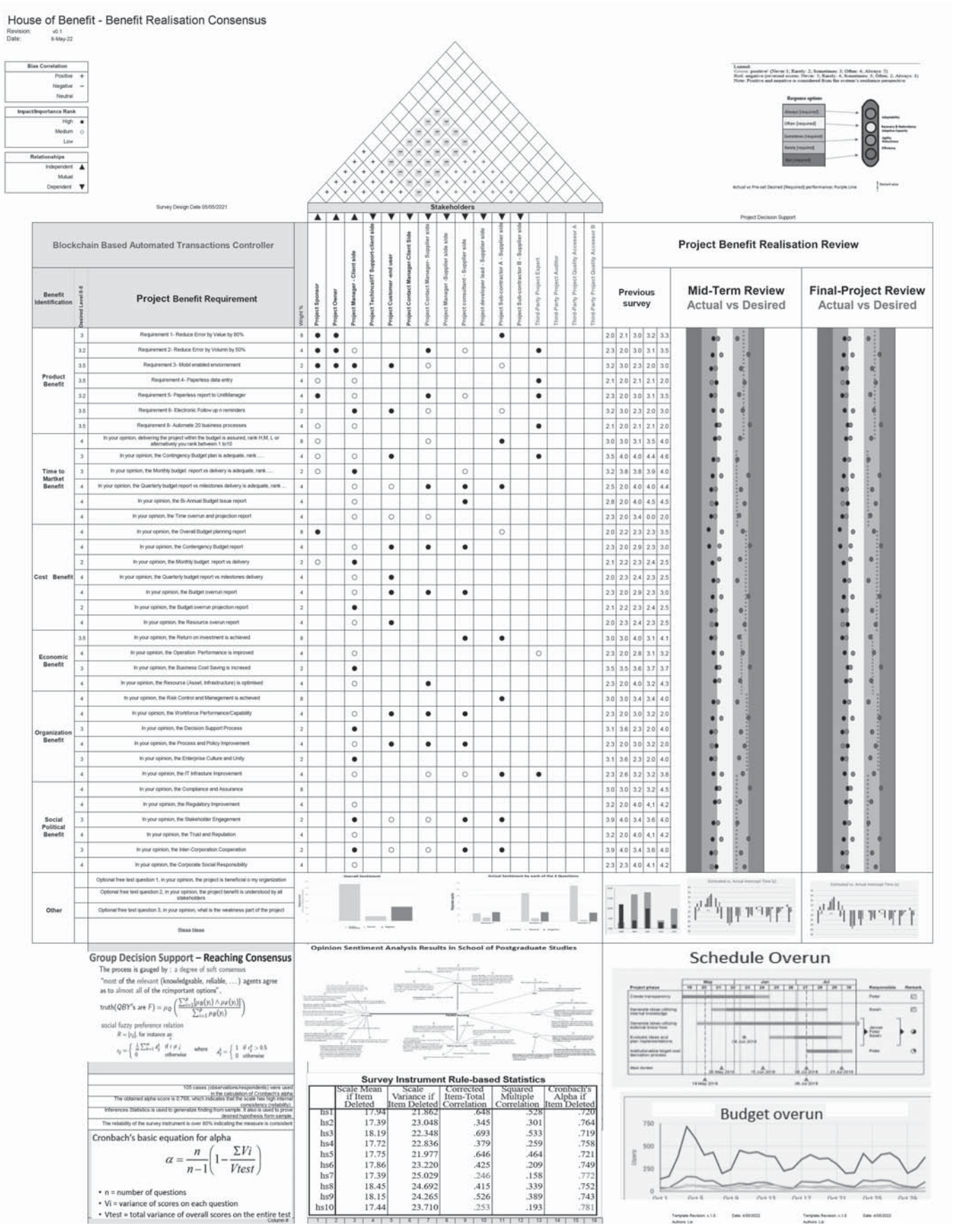
We address two substantial issues here. Firstly, nature and scope of intangibility causes vagueness in the definition of the benefits. Therefore, a consensus on the agreed achievable tangible and intangible benefits and its measurement metrics are accepted among stakeholders. These are underpinned by theoretical interpretation of the achievable benefits. Secondly, the measurability and quantification of achievable benefits, particularly intangible benefits, is new and emerging. Lack of a systematic approach may lead to accountability and governance failure as the project evolves over time. In this study, we use consensus reaching group decision support techniques to quantify the achievable benefits which are a perquisite to long-term project success. Whilst financial consideration was the baseline for most project managers in the past, today the project benefit managers are not the only ones who are interested in the project but there are other parties, namely, the domain experts and the larger interest groups like the stakeholders. benefit realization is usually measured at an individual level for each of the interested groups and the aggregate consensus leads to the project level. A project example is given in Figure 3 through the House of benefits.

Note that linguistically quantified fuzzy logic using quantifiers such as "most" and "almost all". and exposition of linguistically quantifiable propositions has been used by Zadeh and followers. Their use in the Performance benefits problem is discussed in reference [8]. As an illustration consider "Almost (Q) all 'ICT' (B) project benefit evaluators (y' s) are convinced (F) that almost all enterprise culture that emerge with time"; the fuzzy representation for Q = "almost all" could be: for

$$\mu \text{ almost all } (x) = \begin{cases} 1 & \text{for } x \geq 0.8 \\ 2x - 0.6 & \text{for } 0.3 < x < 0.8 \\ 0 & \text{for } x \leq 0.3 \end{cases} \quad (1)$$

Further representing the fuzzy perspectives Property F is defined as a fuzzy set in Y. For instance, if $Y = \{X,\ Y,\ Z\}$ is a set of experts and F is the property 'satisfied', then F may be explicitly written as F = 'satisfied' $= \frac{0.1}{X} + \frac{0.6}{Y} + \frac{0.8}{Z}$; Which means expert X: the project manager expert Y: the program manager and expert Z: the portfolio manager are satisfied to degree 0.1, 0.6 & 0.8 respectively that the social benefit will be yielded at the end of the project lifecycle. In the light of project cost, quality time constraints the project triangle explains, the experts are also satisfied to varied degrees how the project benefits, program benefits and portfolio benefits will be satisfied in the foreground of social project value. If the different types of benefit experts are satisfied about the realization of benefits then, $Y = \{y_1, \ldots y_p\}$ it is assumed that the truthful (y_i is F) $= \mu_F(Y_i),\ i = 1, \ldots, p$. The value associated for truth (Q y's are F) is determined by two devised steps of Zadeh [13, 14].

Next, we focus on defining agreed benefit particularly intangible benefit, measure and realization. In the continuum comprising of different stakeholders from client, supplier and third party we deal with consensus and the agreed project "benefits" and that is measurable when the important' expert criteria and a parameter is added, B is defined as a fuzzy set in Y, and $\mu_B(y_i) \in [0, 1]$ is a degree of importance of y_i 1 is important to 0 is unimportant, through all intermediate values. For instance, B = 'important' $= \frac{0.2}{X} + \frac{0.5}{Y} + \frac{0.6}{Z}$ means that Expert X (Project manager) is important (relevant) to degree 0.2; Expert Y (Program manager) is important to degree 0.5 and Expert Z (Portfolio manager) is important to degree 0.6. The senior manager is engaged in a process of identifying



	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
hs1	17.94	21.862	.648	.528	.720
hs2	17.39	23.048	.345	.301	.764
hs3	18.19	22.348	.693	.533	.719
hs4	17.72	22.836	.379	.259	.758
hs5	17.75	21.977	.646	.464	.721
hs6	17.86	23.220	.425	.209	.749
hs7	17.39	25.029	.246	.158	.772
hs8	18.45	24.692	.415	.339	.752
hs9	18.15	24.265	.526	.389	.743
hs10	17.44	23.710	.253	.193	.781

Figure 3 A project example through the House of Benefits.

and choosing an option as to which intangible benefit is more essential for the success of the project. Moreover, the benefit manager can position these 01–04 as a set of alternatives yielding different outcomes (e.g. quality can yield financial goals, customer equity can yield customer satisfaction, good will can yield enterprise trade name value, stakeholder justice yields stakeholder satisfaction etc and among these a best option (good, feasible or acceptable) is to be found. The rational and collaborative style of decision-making is crucial for the senior manager to identify, measure and later realize the 'agreed', 'target' or 'stated' benefit with intangible properties. In vertical collaboration, the strategic (T1), tactical (T2) and operational (T3) levels of the hierarchy takes centric value in Project benefit. With shared or collaborative benefits, deliverables and project outcomes, there is a need for managers to think about collaborative decision making to systematically approach benefit management. Kacprzyk explains that at the lower-levels of the organization, tier T1, the decisions made are structured in character and tenor as the decisions are routine-based, operational and decision makers are bound by definite procedures but in higher levels the decision making is more unstructured than in tier T3, where the decision maker must provide judgement, evaluation, and insights into the problem definition and then the solution. While multiple criteria decision analyses, or group decision making analyses are decision-making techniques involving the novel approach of several individual experts raising their voice or voting towards a common understanding or consensus, the process is a collection of logically united steps that leads to a project decision outcome. The process consists of four stages; intelligence, design, choice and implementation The real decision making is undertaken collectively interdependently and persuasively. Hence, the group decision making is characterized by multiple goals, multiple decision makers, and multiple stages.

A set of m agents $E = \{e_1, \ldots, e_m\}$ comprising of $E = \{Proj\_mgr,\ Prog\_mgr,\ Portf\_mgr,\ Enterprise\_mgr\}$ we believe "Agent" here are project stakeholders, including customers who are competent and experienced to provide testimonies over a set of n options, $O = \{0_1, \ldots, 0_n\}$ to say $O = \{quality[b_1],\ investment[b_2],\ goodwill[b_3],\ justice[b_4],$ *equity* and $fairness[b_5]\}$, as individual fuzzy preference relations, $R1, \ldots, m$. At $t = 0$, the agent's initial fuzzy preference relation, $R_k k = 1, 2, \ldots, m$ on the set of options, may differ to a large extent so that the degree of consensus is likely to be lower. The project, program, portfolio and enterprise managers views and thoughts about the benefit b_2 at the point of investment may differ to a larger extent as their individual perception is different and contextual factors like the project interest is diverse. In relation to financial investment the insights of strategic benefit level is at a higher-order while the tactical level is relatively lower. In the case of goodwill, b_3, will be perceived at divergent levels like in case of top level management seek higher about the project's reputation compared with lower level management as it aligns with the strategic outcome of the organizational project. The individual benefit's such as time, HR cost etc (should be at the benefit var level, the aggregate these is for the project, and that can be automated computed) functionalities are multi-faceted and the mediating parties are crucial for consensus at the project level. The project decision is ideally championed by a significant industrial party/stakeholder like the organizational leader. Frequently it is the project owner or funder who has the overview, brainchild and insights of the project, its benefits and after-effects or consequences. Thus, a majority prefers the intervention of a pioneering project expert to streamline the decision-making process, playing the role of a mediator. A super-agent takes the role of the moderator who initializes the exchange of ideas, facilitates the arguments in a networked setting. An expert like a Chief Project Officer with the authorization of the board of directors or majority shareholders facilitate effective decision-making. In the light of project failures, unsuccessful programs and project disbenefits [2, 15] it is a loss for stakeholders. The process of consensus driven decision making is a focused, unbiased, respected ideology of giving equal share of concern to the views of all experts for stakeholder justice [04] and an approach to decide if it is practically attained. The decision making process is gauged and substantiated by a degree of soft consensus' which is equated with the truth value [6], [5], [14]. "most of the competent knowledgeable, reliable project experts agree upon as to almost all of the dimensions of stakeholder justice is observable in the project at different intervals of the lifecycle". Zadeh's approach is to inspire the logic that explains that each project expert agrees to give the consent to the decision reached even if it is not totally aligned with his/her individual perspective. Moreover, the individual expert is free to modify his/her testimony while each intellectual view, insight and idea is valued, heard and considered. The quantifier 'most' is approximately analogous to a unanimous decision among the experts.

The derivation of the degree of consensus The first step is to compute a degree of agreement as to the preferences between all relevant pairs of options for the pairs of agents.

In the scientific approach of voting system of variables, one should apply the social fuzzy consensus methodology. For social consensus, a step wise approach in the consensus reaching process uses a fuzzy preference relation and reaches a social fuzzy preference relation, at consensus. In compliance with democratic voting standards, if more than a half or $\frac{2}{3}$ rds of the experts group votes in favour of a preference option $PC_{\text{VARPRODUCT BENEFIT}}$; $PC_{\text{VAR TIME TO MARKET}}$; $PC_{\text{VAR PROJECT COST BENEFIT}}$; $PC_{\text{VAR BUSINESS OR OPE BENEFIT}}$; $PC_{\text{VAR ORG BENEFIT}}$; $PC_{\text{VAR SOC-CUL POL BENE}}$ the majority rule is applied with provision for bad outcome of the decision as well. If the majority project experts vote in favor of two but abstains on one variable, then it may undermine the benefit process as procedure of allocation of rewards is ignored deliberately by the group of experts or stakeholders of the project. Hence, rational decision-making must consider the balance of probabilities. The benefit measurement using social fuzzy preference relates to the characteristic, explanation, measures, and the fuzzy relation of each expert. Accordingly, for the variables in the process of benefit realization, it is

necessary to quantify and evaluate the values from a linguistic perspective. Therefore, we need to quantify some values that cannot be directly quantified. The Project Component variables (PC var) are hybrid as they have both tangible and intangible aspects. The intangible benefit realization (y) cannot be directly measured and, hence, we need to estimate y based on available information and known values of related quantities $x_1, \ldots, x_n$, and the estimating algorithm is expressed $y = f(x_1, \ldots, x_n)$.

Realization of the benefit to the stakeholders $= f$ (average of product benefit[x_2], average of time to market benefit[x_3], average of project cost benefit[x_4], average of business or operation benefit[x_5], average of organization benefit[x_6], average of social, cultural and political benefit[x_7]. It becomes the most important consideration for benefit realization. The relevance of options, relevance of pairs of options, importance of experts, and the importance of pairs of individuals, all contribute towards the degree of agreement and determination of options [6]. Strict agreement and sufficient agreement are the fundamental degrees of agreement among the experts with reference to options and the outcome or project decision. Accordingly the relevance of options with norm values s_i: from 0 standing for 'Not' to 1 for 'always' through all intermediate values. When measuring 'stakeholder BR' the PRODUCT BENEFIT could be definitely relevant/Always Product benefit= '1' & product cost benefit= '1' with Product social benefit= '0'. The relevance of pairs of options notational are measuring the compatibility among the options $b^B_{(prod_{ben}/proj_{cost}ben)} = b^B_{(proj_{cost}ben/prod_{ben})}$ are straightforward relevant and $b^B_{(prod_{ben}/prod_{ben})}$s is irrelevant as the notation explains that it is the same option.

One should establish benefit realization decision making in terms of accurately estimating between actual and desired variable values and understanding the distinction between benefit and intangible benefits at higher order levels of projects, as the benefits are rather fuzzy and uncertain. In our case, the project component variables are the actual values as perceived by the project stakeholders to be the realism of benefit approach. The estimated achieved values are the desires of the stakeholders which are the ultimately achievable benefit realization. It is further describable that the actual benefit realization is the possibility or probability of attaining the said benefits to reach the end realization of the target. On the other hand, desired value is the extent to which the benefit is actually realized and estimated as a target reachability at mid-point and final review of the benefit realization.

The ultimate purpose of concepts and degrees of consensus models based on fuzzy majority is to ensure group decision-making and consensus models fits closer to reality and is human consistent [3, 4]. This thereby aims at accounting for a fuzzy majority represented by a fuzzy linguistic quantifier [6, 12, 14]. The four types of benefit STAKEHOLDERS $\{k =$ supplier (1), client (2), pro_expert(3), enterprise(4)$\}$ express the fuzzy preference relation for a pairwise options relating to the realization of stakeholder benefits of project levels of the public and corporate enterprise project namely product_benefit; time to market, project cost benefit, project operation, organizational benefit, and socio-benefit. For the same 'individual fuzzy preference relation', we can impute and determine the decision-making using the social fuzzy preference relations. The core of this approach is useful to obtain a social fuzzy preference relation based on Nurmi [3, 7]. It also has an intuitive appeal to conceptualize and apply the fuzzy consensus winner extended further as a fuzzy majority expressed by a fuzzy linguistic quantifier. The application of social consensus can be reflected and recalled by the social fuzzy preference relation. In the context of a common manager known as a benefit manager the social fuzzy preference relation abiding the group decision making by the experts, the fuzzy preference consensus of individual experts of project managers is considered. Hence, the implication of the method is to obtain a 'social fuzzy preference' and 'consensus winner' in decision making over the options of benefits that are determined by the experts. The Fuzzy consensus of the six project component variables can be summarized below [8].

(1) Proj component variables 01 & 02 always achieved with a full agreement by expert stakeholders

(2) Proj component variables 01 & 03 is often achieved with partial agreement

(3) Proj component variables 01 & 06 is sometimes achieved with partial agreement

(4) Proj component variables 02 & 05 rarely achieved with full agreement

(5) Proj component variables 05 & 06 not achieve with partial agreement

(6) Proj component variable 01 & 04 sometimes achieved with partial agreement

The go-and no-go decisions are that project components 01,02,05 are to proceed with value from product benefit, time to market benefit and org' benefit are regarded to be 'go" decisions without a schedule overrun, and the project busi-operation benefit, social value and proj cost benefit related indicators are contributory to 'no-go' projects that will lead to failure. Therefore, these are operationally non-functional, ignorable projects with a probability of failure.

7. CONCLUSION

This paper presents House of benefits (HoB) to support PPP and mega project management. The tool uses fuzzy consensus-based group decision making with multi-stakeholders in PPP. It also incorporates a stratified approach and expert-based decision approach allowing all stakeholders to have their opinion recognized in the fuzzy consensus approach. HoB is a visual tool and an approach to support benefit realization.

ACKNOWLEDGEMENT

The research team would like to acknowledge the Australian Department of Defence for the support of this research.

REFERENCES

1. Monique Aubry, Sanaa El Boukri, and Viviane Sergi. 2021. Opening the black box of benefits management in the context of projects. *Project Management Journal* 52, 5 (2021), 434–452.
2. Yogesh K Dwivedi, Karthik Ravichandran, Michael D Williams, Siân Miller, Banita Lal, George V Antony and Muktha Kartik. 2013. IS/IT project failures: a review of the extant literature for deriving a taxonomy of failure factors. In *International working conference on transfer and difusion of IT*. Springer, 73–88.
3. Mario Fedrizzi, Janusz Kacprzyk, and Hannu Nurmi. 1993. Consensus degrees under fuzzy majorities and fuzzy preferences using OWA (ordered weighted average) operators. *Control and Cybernetics* 22, 4 (1993), 71–80.
4. Mario Fedrizzi and Gabriella Pasi. 2008. Fuzzy logic approaches to consensus modelling in group decision making. In *Intelligent Decision and Policy Making Support Systems*. Springer, 19–37.
5. Enrique Herrera-Viedma, Francisco Javier Cabrerizo, Janusz Kacprzyk, and Witold Pedrycz. 2014. A review of soft consensus models in a fuzzy 626 environment. *Information Fusion* 17 (2014), 4–13.
6. Janusz Kacprzyk and Mario Fedrizzi. 1989. A human-consistent'degree of consensus based on fuzzy login with linguistic quantifers. *Mathematical Social Sciences* 18, 3 (1989), 275–290.
7. Janusz Kacprzyk, Mario Fedrizzi, and Hannu Nurmi. 1992. Group decision making and consensus under fuzzy preferences and fuzzy majority. *Fuzzy sets and systems* 49, 1 (1992), 21–31.
8. D Ru, A Ghildyal, and E Chang. 2022. benefit Realization based on Fuzzy Consensus approach. *Soft Computing* (2022).
9. D Ru, S Yapa, A Uthumange, A Ghildyal, and E Chang. 2020. Measuring Project benefit using an Integrated Fuzzy-Shafer Algorithm, "Soft Computing: New Direct., Foundations and Appls *Journal of Business Research* (2020).
10. D. Ruwanthi, S. Yapa, A. Uthumange, A. Deshpande, and E. Chang. 2018. Stratifcation and Fuzzy Inference System for Measuring Project benefits. In *Joint 10th International Confe rence on Soft Computing and Intelligent Systems and 19th International Symposium on Advanced Intelligent Systems in conjunction with Intelligent Systems Workshop 2018*.
11. Martin Voss. 2012. Impact of customer integration on project portfolio management and its success–Developing a conceptual framework. *International Journal of project management* 30, 5 (2012), 567–581.
12. Lotfi Zadeh. 1965. Fuzzy Sets. *Information and Control* 8 (1965), 338–353.
13. Lotfi Asker Zadeh. 1968. Probability measures of fuzzy events. *Journal of mathematical analysis and applications* 23, 2 (1968), 421–427.
14. Lotfi A Zadeh. 2016. Stratifcation, target set reachability and incremental enlargement principle. *Information Sciences* 354 (2016), 131–139.
15. Offer Zwikael, Ying-Yi Chih, and Jack R Meredith. 2018. Project benefit management: Setting effective target benefits. *International Journal of Project Management* 36, 4 (2018), 650–658.