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FRAMING WICKED PROBLEMS THROUGH EVIDENTIARY AND INTERPRETATIVE ANALYSIS

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ABSTRACT
Wicked problems are characterized by incomplete and conflicting information. To frame a wicked problem, it is necessary to analyze the interaction between variables and thence identify a reduced set of variables that are key to designing a socio-economic-technical system.

In this paper we propose using a combination of interpretative and evidentiary analysis through the application of Dilemma Triangle Method and System Dynamics, respectively. We propose a computational framework that allows a designer to convert heuristics into insights by using System Dynamics modelling, thus allowing a designer to analyze the interaction between variables. Further, our framework is based on the notion of involving human-in-the-loop, wherein wicked problems are framed through synergistic actions between a human -and a computer. The benefits of using this framework are

- *Converting heuristics into insights,*
- *Understanding the interaction between variables by analyzing the behavior of the system,*
- *Identifying the correct size of the problem by eliminating the variables that cannot be used to design a socio-economic-technical system.*

To demonstrate the efficacy of the framework we use data pertaining to Kantashol village in Jharkhand, India. The data was provided by SunMoksha Power Pvt. Ltd. Our focus in this paper is on describing the framework rather than the results on the ground in India.

Keywords: Wicked Problems, Evidentiary Analysis, Interpretative Analysis, Heuristics, Human-in-the-loop, System Dynamics, Dilemma Triangle Method

GLOSSARY
Wicked Problem: A class of problems which are ill formulated, where the information is confusing and conflicting, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing [1].
Decision Maker: An individual who can affect, through his/her decisions, the achievement of objectives for an organization.

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Stakeholder: An individual who can affect or is affected by the achievement of the objectives for an organization.
Framing: Identifying the problem correctly before solving a problem to ensure that the problem are correctly addressed.
Interpretative Analysis: An approach for analyzing qualitative data that involves exploring and interpreting the meaning of data from the perspectives of individuals/actors involved [2].
Evidentiary Analysis: Analysis that involves the systematic process of collecting, examining, and evaluating data and analyzing it with rigorous research methods, in order to provide decision support through that evidence [3].
Heuristics: Heuristics are the assumptions, experiences, domain expertise, that are applied in a way to hasten the process of approaching a solution.
Thematic Area: An area or category in which issues related to the same subject are considered.
Human-in-the-loop: Humans act as an embedded component in the system where their intent, emotions, cognition, etc. are intrinsic part of the computational system [4,5].

1. FRAME OF REFERENCE

1.1 Wicked Problems – Definition, Characteristics and Broader Impacts

Horst Rittel defines wicked problems as 'a class of social system problems which are ill formulated, where the information is confusing, where there are many clients and decision makers with conflicting values, and where the ramifications in the whole system are thoroughly confusing', which is considered as one of the earliest definitions of wicked problem; see editorial by Churchman, [1]. Rittel and Weber in their seminal paper emphasize the notion of focusing on the nexus of goal formulation, problem definition and equity issues. Social processes are seen as links connecting the open systems into large, interconnected networks which follow continuity of input-output relations. Rittel and Weber enunciate the importance of correctly identifying and framing the wicked problem by stating *"In that structural framework it has become less apparent where problem centres lie, and less apparent where and how we should intervene even if we do happen to know what aims we seek"* [6]. Further, they state that describing and locating the problem is one of the most challenging and intractable difficulties to address. The ten characteristics of a wicked problem recognized by Rittel and Weber are:

i. *There is no definitive formulation of wicked problems. They are difficult to frame.*[2]
ii. *Wicked problems have no stopping rule.*
iii. *Solutions to wicked problems are not true or false, but good or bad.*
iv. *There is no immediate and no ultimate test of a good solution to a wicked problem.*
v. Every solution to a wicked problem is a "one-shot operation"; because there is no opportunity to learn by trial-and-error, every attempt counts significantly.
vi. Wicked problems do not have an enumerable (or an exhaustively describable) set of potential solutions, nor is there a well-described set of permissible operations that may be incorporated into the plan.
vii. Every wicked problem is essentially unique.
viii. Every wicked problem can be a symptom of another problem.
ix. *There are numerous explanations for a wicked problem.*
x. *The planner has no right to be wrong.*

The characteristics that we address in this paper are italicized. Rittel and Weber contend that a systems approach is appropriate to frame wicked problems. They argue that for wicked problems one cannot understand the problem without knowing about its context and that the systems approach of the 'first generation' is futile to deal with wicked problems. Accordingly, a designer might be overwhelmed and feel paralyzed about addressing wicked problems. We believe that wicked problems can be addressed by identifying the correct size of the problem, instead of getting overwhelmed by its notion. Paralysis occurs when one acts too reflexively and considers wicked problems so overwhelming that it discourages them from doing anything about it [7]. Termeer et al. emphasize the significance of small wins to tackle wicked problems and its value in bringing in transformative change [8]. We agree with the notion that it is important for a designer to take small steps to address the "wickedness" embodied wicked problems. This is reflected in our proposed approach for framing a wicked problem.

The United Nations General Assembly adopted the 2030 Agenda for Sustainable Development [9] where the major focus is on "transform[ing] the world to better meet human needs" and "leave no one behind and create a world of dignity". "We need to tackle root causes and do more to integrate the economic, social and environmental dimensions of sustainable development." In a subsequent editorial published in Nature in 2020, the writers contend that the world is almost set to miss all the goals except two, namely, "eliminating preventable deaths among newborns and under-fives," and "getting children into primary schools", which are the closest to being achieved [10]. Eden et. al. argue that irrespective of Covid 19 pandemic, the agenda to achieve the goals was inevitable due to the fact that the United Nations are addressing issues which are wicked problems [11]. Instead of trying to solve wicked problems, designers/ policymakers should focus on managing or coping with the wicked problems [12]. We believe that in order to manage or cope with wicked problems it is important to correctly frame the problem at the start of a design process. This has broader impacts in terms of correctly identifying the problem and going to the core of the wickedness of the problems in order to solve them. In this paper we consider an example of wicked problem in a village

[2] We have italicized the characteristics that we have considered in the proposed framework.

in India, namely, Kantashol. The three thematic areas that we consider in framing the Kantashol wicked problem are water, forestry, and agriculture. These thematic areas are anchored in demographics, culture and socioeconomics associated with this village. We require a comprehensive understanding when we deal with wicked problems with the goal of sustainable development. We observe that water, forestry, and agriculture are interdependent areas with challenges that are intertwined, however, they are approached separately in silos [13]. We suggest that wickedness of the problem lies in modeling the synergy between the different thematic areas of consideration that makes it essential to initially frame the wicked problem and correctly identify the variables of consequence and its size. With the goal to provide a framework to frame wicked problems as well as anchor with sustainable development goals we select three `Drivers`[3] for our problem namely, People, Planet and Prosperity[4] [14].

1.2 Interpretative Analysis and Evidentiary Analysis

Various authors have commented on the role of interpretative and evidentiary analysis in approaching wicked problems. Evidence-based analysis for public policy analysis is mired in debates in terms of its utility. Several authors stress the need for an orderly approach and explore the evidentiary analysis to aid policy making [15]. Daviter, argues that the main aim of evidence-based analysis, that is evidentiary analysis, is to provide design options for conflicting interpretations by enabling analytical tasks to be more objectifiable [16]. Various authors in the past argue that the problems that are ill structured (wicked problems) are not open to analytical methods. Strong evidence seldom contributes in the analysis of problems when the boundaries are not well defined [17]. Authors who contest evidentiary analysis assert that the evidence is often value-laden which suggests that the evidence is more likely based on biased conclusions [18]. Authors argue that, with this notion, evidence-based analysis for wicked problems like public policy are arrived through an order of ranking of technological method rather than consensus between various stakeholders and actors involved in the process [19]. However, the notion of evidentiary analysis for wicked problems is widely bolstered by academicians, administrators, and politicians [20]. Daviter [12] argues that when we deal with wicked problems, the knowledge base we have is often 'fragmented' and 'contested' due to the notion of available evidence being 'incomplete', 'inconclusive' and 'incommensurable'.

In this paper we account for the issues cited in the preceding paragraph by proposing a framework to frame a wicked problem that embodies the integration of interpretative and evidentiary analysis through Dilemma Triangle Method and System Dynamics, respectively. We suggest that framing of any wicked problem and identifying the core of it allows a designer to understand the problem and proceed in a structured way to address the wickedness of any wicked problem. Through the inclusion of interpretative and evidentiary analysis we enable humans in the loop to account for human cognition, mental capabilities, and socio-cultural elements [21]. We suggest that by including a human-in-the-loop we facilitate the efficient framing of wicked problems by maximizing the synergy between human abilities and computational capabilities.

1.3. Dilemma Triangle Method and System Dynamics

1.3.1. Dilemma Triangle Method (DTM)

The Dilemma Triangle Method is used to identify the dilemmas embodied in wicked problems. A Dilemma is defined as follows: Dilemma: *"A dilemma is a difficult choice between two options, each of which is unacceptable or unfavorable"* [22].

A schematic of the Dilemma Triangle Method is shown in Figure 1. We use the following key words in the Dilemma Triangle Method:

`Driver`: *These are the thematic areas that are key to framing a wicked problem and thence used in identifying an appropriate solution or way forward. There is no limit on the number of* `Drivers` *that can be considered.*

`Focus`: *A single statement used to define the goal that must be achieved for the* `Driver`*. There can be several* `Foci` *for each* `Driver`*.*

`Issues`: `Issues` *must be addressed to satisfy the* `Focus` *that must be achieved for the Driver.*

In the Dilemma Triangle Method, we select the thematic areas that contribute to the wicked problem and identify the `Drivers` for each thematic area; see Figure 1. As shown in Block 1, Figure 1, we identify three `Drivers` for each thematic area. Further, we define the `Focus` using experience and judgment each `Driver` that enables us to establish the boundaries This includes taking into account the perspectives of multiple stakeholders involved. Once we have the `Focus` for each `Driver`, we list the `Issues` as shown in Block 2; Figure 1, that are key to achieving the specified `Focus`. Further the two important stages in the Dilemma Triangle Method which help in managing the dilemmas are creating `Tension Matrix` and identifying the `Dilemmas`.

A) Tension Matrix (Block 3; Figure 1)

A `Tension Matrix` is created to identify the relation between two `Issues`. This matrix is a foundational step in identifying `Dilemmas`. There are four relations between `Issues` which can be identified through the `Tension Matrix`:

[3] Key words associated with the Dilemma Triangle Method are shown in Courier font.

[4] *Progress* used in our earlier publications has been replaced by *prosperity* to conform to the definition adopted for sustainable development at COP 26 in Glasgow.

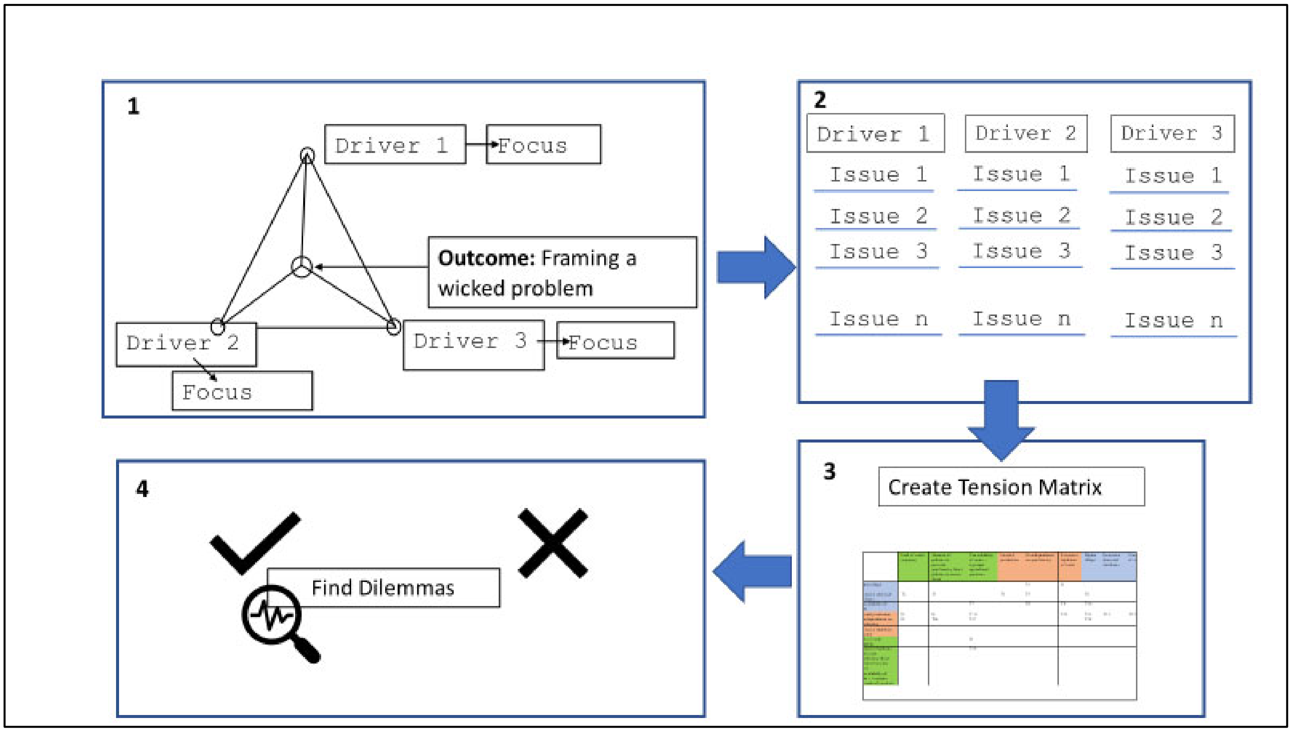

FIGURE 1: GENERALIZED DILEMMA TRIANGLE METHOD

a) `Tension:` A tension results when an `Issue` associated with one `Driver` negatively impacts an `Issue` associated with another `Driver`.

b) `Dependent:` A dependent arises when the `Issue` associated with one `Driver` positively impacts an `Issue` associated with another `Driver`.

c) `Inter-Tension:` When one `Issue` negatively impacts an `Issue` of a different thematic area.

d) `Inter-dependent:` When one `Issue` positively impacts an `Issue` of different thematic area.

B) Identifying Dilemmas (Block 4; Figure 1)
`Dilemmas` are identified based on the `Tension Matrix` constructed. `Dilemmas`, when correctly identified through combination of evidentiary and interpretive analysis help us to frame a wicked problem, the framework for which is described in this paper.

In several agricultural villages, relevant to this effort, the income of villages depends on the forest. If the villagers stop cutting trees and accessing the forest utilities their income will reduce. Thus, this happens to be a dilemma. Further, villagers who practice agriculture have over exploited water for their personal and agricultural use. They practice excessive tillage in farms which has other detrimental impacts on the planet. Thus, this is again a dilemma and precludes sustainable development. The three `Drivers` we select to promote sustainable development in such a village are People, Planet and Prosperity. This is anchored in the test problem used in this paper. The use of the Dilemma Triangle Method to manage dilemmas in one thematic area for sustainable rural development of India is documented in Reference [22]. Further, the Dilemma Triangle Method is expanded to three thematic areas to provide a method for social entrepreneurs to develop value propositions [24]. The application of Dilemma Triangle Method along with systems dynamics to propose policies and value propositions is presented in [23–24] In our earlier papers we focused on:

- Karkaria et al. [23] use the combination of Dilemma Triangle Method and System Dynamics to determine policies. Their main objective is to propose policies to ensure sustainable development. In this paper, we focus on framing wicked problems through iteration by incorporating evidentiary and interpretative analysis while maximizing synergy between computational capabilities and human abilities.
- Kamala et al. [24] focus on using System Dynamics to create value propositions for social entrepreneurs. Their objective is to aid social entrepreneurs to provide decision support to choose right value proposition required for the intervention and evaluate its pre-impact. Whereas through the framework proposed in this paper, a designer can identify the wickedness of the problem and frame wicked problems through interpretive and evidentiary analysis.

1.3.2.System Dynamics Modelling

We use System Dynamics to model the system and enable a designer to simulate and analyze the behavior of the system to gain insights that support decision making. Through simulation of system using System Dynamics, we understand the effect of variables on each other and gain insight on the interaction between variables and their impact on system model. Systems Dynamics necessitates constructing a causal loop diagram and a stock and flow diagram.

a) *Causal Loop Diagram*
Causal loop diagrams are an effective way of mapping the relationship between variables. These allow a designer to link the variables with one another and understand the interconnections of variables in a system. Further, causal loop diagrams help a designer understand the system as a whole and provides an opportunity to enhance the system structure. A causal loop diagram is an effective tool for story telling in order to communicate the understanding of the elements of system and system as whole.

b) *Stock and Flow Diagram*
The creation of stock and flow diagrams allows a designer to simulate the system and get insights on the interaction between variables. Through the simulations created through stock and flow diagram, a designer gain insights of the systems behavior by simulating the system which acts as an important tool for decision support when complex systems are involved. The two important elements namely stock and flow are defined as follows:

Stock: Stock is the accumulation of a quantity at any state of the system.

Flow: A flow is entity which increases or decreases the magnitude of stock.

2. FRAMEWORK FOR FRAMING A WICKED PROBLEM

In this section we describe a framework that can be used by a designer to frame a wicked problem and identify the variables that can be used to design a socio-economic-technical system. We enable a designer to convert the early-stage heuristics into insights to frame a wicked problem through evidentiary and interpretative analysis with a human-in-the-loop.

2.1 Approach for Framing a Wicked Problem

In Figure 2, we illustrate our approach for framing a wicked problem. Given a wicked problem, in the initial stages a designer has heuristics anchored in past experience. However, to frame a wicked problem a designer needs to generate evidence-based insight to augment what is currently known to him/her. Thus, based on the heuristics, a designer invokes the Dilemma Triangle Method. Using the information generated and deductive speculation a designer then constructs a Systems Dynamics model to model the system and thereby gain insight into the behavior of the system. With these insights a designer modifies the input to the Dilemma Triangle Method by considering the evidence-based insights gained through exercising the System Dynamics model. This process is repeated until a designer is satisfied with the outcome. In summary, a designer carries out interpretative analysis through the Dilemma Triangle Method and evidentiary analysis through System Dynamics. This process allows a designer to synthesize the heuristics and experiences into insights through deductive speculation to frame a wicked problem.

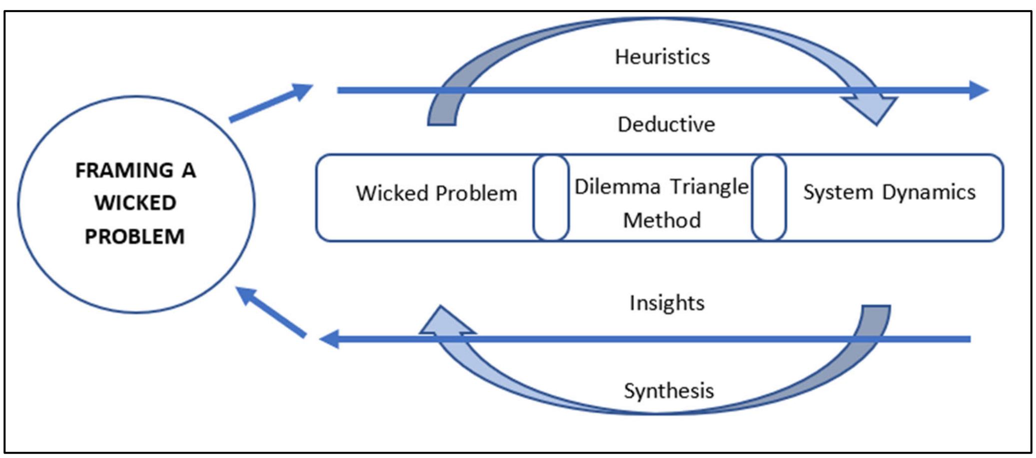

FIGURE 2: OVERVIEW OF APPROACH

The rest of the paper is organized as follows: In Section 2 a description of the proposed framework is presented. In Section 3, the test problem and the approach used while exercising the proposed framework is described. In Section 4, the results and the efficacy of the proposed framework are discussed. A discussion of the results is included in Section 5. In Section 7 appropriate closing remarks are documented.

2.2 Features of the Proposed Framework

We propose a framework to frame the wicked problems through a structured process. The features of the proposed framework are summarized in Figure 3.

Conversion of heuristics into insights: While dealing with wicked problems, it is evident that a designer have incomplete information which is often confusing and

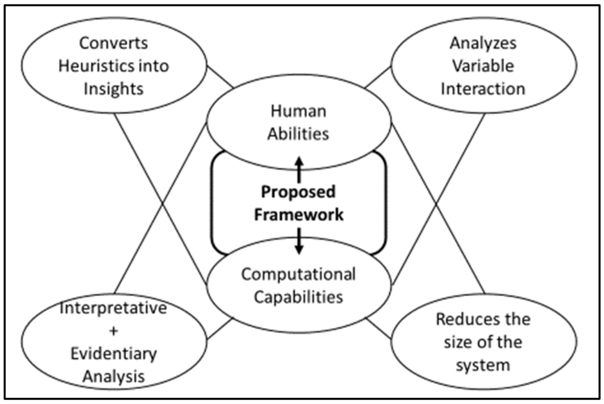

FIGURE 3: FEATURES OF THE PROPOSED FRAMEWORK

conflicting. The value of this feature of the framework is to attain insights from the initial heuristics. As shown in Figure 2, the initial invocation of the Dilemma Triangle Method is based on the heuristics a designer have. Through the advancement from Dilemma Triangle Method to System Dynamics model, we create a foundation for having insights based on heuristics. The system behavior analysis as shown by Block 2A in Figure 4 is the stage where the heuristics are converted into insights.

Analyze interaction between variables and identify the correct size of the problem: When we consider a wicked problem, we have a plethora of variables that are of interest to a designer. However, some of these might not be significant. It is therefore important for a designer to understand the interaction between these variables and their overall effect on the wicked problem. This allows a designer to identify the variables that are significant which further emphasizes the third peculiar feature of the proposed framework, through which we enable a designer to identify the correct size of the problem. This anchors in Block 2 and Block 2A of Figure 4.

Maximizes synergy between human capabilities and computational abilities: Due to the characteristics of wicked problems, it can seldom be modelled alone with computational abilities. Human cognitive characteristics play a very important role in addressing wicked problems through judgements, perspectives, and experiences of humans. The value added through this feature is to maximize the synergy between human abilities and computational capabilities. Through the Dilemma Triangle Method a designer brings to bear his/her judgement (qualitative information) that is anchored in experience. By exercising the Systems Dynamics model is able to transform judgment (qualitative information); see Blocks 1, 2 and 3 in Figure 4.

Integration of Interpretative and Evidentiary analysis: Interpretative and evidentiary analysis play a very important role and have their own significance for addressing various types of problems. Through the proposed framework, authors provide an opportunity for a designer to have both; interpretative analysis through the Dilemma Triangle Method and evidentiary analysis by simulating the system by virtue of System Dynamics model.

2.3 Description of the Framework

The conceptual design of the framework is divided into three main building blocks is shown in Figure 4. Further, in Figure 5 we present the detailed framework. In this section we discuss three steps in the context of their utility in the framework.

Step 1: Dilemma Triangle Method

Identify the `Focus` and list the `Issues` that are key to attaining the `Focus`. This is based on heuristics and observations gained

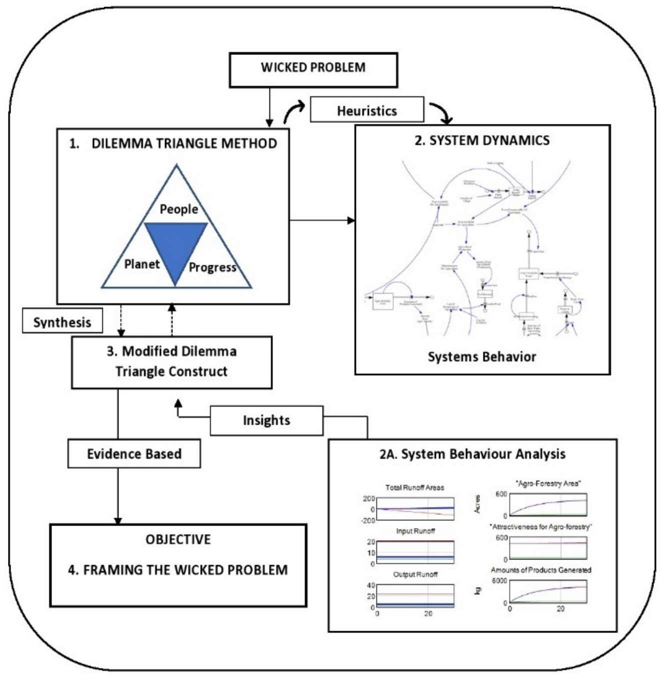

FIGURE 4: MENTAL MODEL FOR THE PROPOSED FRAMEWORK

by the knowledge of the wicked problem we have. At this stage we do not create the `Tension Matrix` to arrive at `Dilemmas`. Through Dilemma Triangle Method we carry out interpretive analysis which allows us to incorporate the behavioral, cognitive, and social elements in the analysis to frame wicked problems. This interpretive analysis further helps a designer to analyze the qualitative data involving interpreting the data from the perspectives of actors involved. The information used is based on heuristics anchored in what the designer knows at this time.

Step 2: Systems Dynamics
Create a Systems Dynamics model to gain insights for framing a wicked problem. A designer develops causal loop diagrams

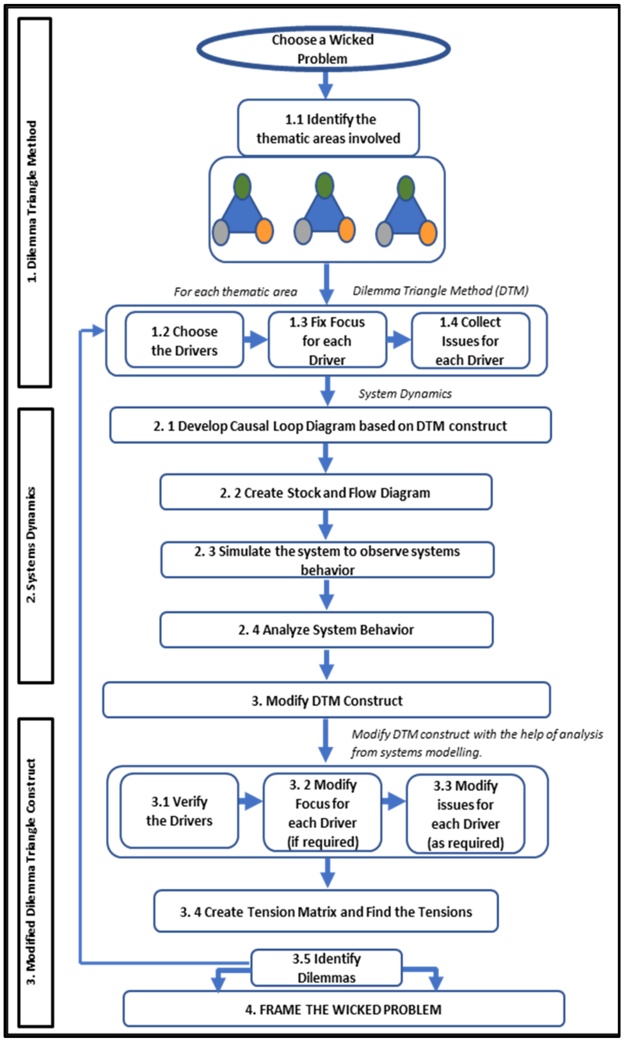

FIGURE 5: PROPOSED FRAMEWORK TO FRAME WICKED PROBLEMS

based on the Dilemma Triangle construct from Step 1. Further, designer creates stock and flow diagrams and simulate the system. Through this structured process a designer is able to simulate and observe the behavior of the system. A designer analyzes the effects of interaction between variables and gains insight on the important variables that affect/govern the behavior of the simulated system and also those variables that a designer is unable to control. With these insights a designer eliminates the variables that do not impact the outcome and those that are not under a designer's control. This enables a designer to isolate the "wickedness" associated with the wicked problem and deal with it appropriately.

Thus, through System Dynamics a designer is able to carry out the evidentiary analysis by gathering insights and evidence by simulating the system and observing the interaction between variables. Through the framework, a designer have the opportunity to collect, evaluate and examine data by incorporating the interpretive analysis as well to provide decision support to frame wicked problems.

Step 3: Modified Dilemma Triangle Method
As discussed in Step 2, at this stage a designer has gained insights from the System Dynamics model through the simulation of the system. The designer leverages the insights gleaned and modifies the Dilemma Triangle created in Step 1. This enables a designer to modify the Tensions and Dilemmas and add observations based on insights which impact the system. The Dilemmas constitute the framing of the wicked problem. Each Dilemma needs to be resolved. The resolution will typically involve some combination of technical, regulatory, policy, financial and social consideration.

Through this framework, we utilise the interpretative analysis through the Dilemma Triangle Method compounded with the evidence-based analysis through System Dynamics to frame wicked problems. Thus, a designer who uses this framework, can convert the heuristics into insights and frame the wicked problem through a structured process to ensure correct identification of the problem and a way forward.

3 TEST PROBLEM OF KANTASHOL VILLAGE TO DEMONSTRATE THE EFFICACY OF THE FRAMEWORK

To illustrate the efficacy of the framework we use data for Kantashol village in Jharkhand, India provided by Dr. Ashok Das and his colleagues at SunMoksha Power Pvt. Ltd. The average rainfall is around 60-65 days in a year with an annual count of 800-1310 mm, due to which villagers use excessive amount of ground water which happen to be one of the reason of overexploitation of the ground water. Villagers are over dependent on the forestry for their livelihood and the practice of agriculture is limited due to various reasons. The average temperature in the village is around 40-45 degree Celsius. The village has marginal road transport. Since the income of villages depends on forestry, if the villagers stop cutting trees and accessing the forest utilities their income will be reduced. Thus, this happens to be a dilemma. Further, villagers over exploiting the water for their personal and agricultural use exacerbates challenges. The local practice of excessive tillage in farms which has various detrimental impacts on the planet including erosion which, in time, reduces the acreage of available land to the villagers, affecting the planet adversely. The situation is a wicked problem due to the incomplete, conflicting, and confusing information.

Approach

Having identified this as a wicked problem based on insights from various stakeholders, we begin to assess the situation borrowing heavily from the expertise from the SunMoksha team. SunMoksha is an international partnership between scholars and local industry in India that strives to develop and field-deploy clean and sustainable technology solutions and provides consulting services for rural development and urban sustainability. The SunMoksha team consists of experts and professional with a passion for sustainable development, and decades of experience in technology, engineering and management across Asia, Africa and the USA including team members working on the ground which grants us real-time insights on problems faced at individual and community level in terms of people, planet, and prosperity.

The framework illustrated in Figure 5 is systematically exercised for the Kantashol village problem. A discussion on the efficacy of the framework through the test problem is presented in Section 4. The following steps are explained with respect to the test problem and are tied with the steps illustrated in Figure 5.

Step 1 Figure 5: Dilemma Triangle Method

Step 1.1: Identify the thematic areas involved

Initially we select the important thematic areas involved based on the lifestyle and situations of the village. The thematic areas we select are water, forestry, and agriculture. However, to illustrate the framework we combine all three thematic areas in the Dilemma Triangle Method. The system dynamics model, however, has all three thematic areas involved to ensure we get accurate insights.

Step 1.2: Define the `Drivers`

We select the three `Drivers` with the goal of improving the progress of the people and at the same to ensure sustainable development. The three `Drivers` we select are People, Planet and Prosperity.

Step 1.3: Fix `Focus` for each `Driver`

Based on the situation in Kantashol we define the `Focus` of each `Driver`. This is based on taking perspectives of various stakeholders and the data collected from the SunMoksha team.
We take into consideration various factors affecting the livelihood and progress of the people of the village at an individual-level as well as community-level alongside ensuring that the development is sustainable.

Step 2 Figure 5: Systems Dynamics Modelling

Step 2.2: Create Causal Loop Diagram

This first step in System Dynamics modeling anchors with creating causal loop diagram. These causal loops help designers to map relationship between different variables. The interpretive analysis carried during the Dilemma Triangle Method in Step 1 forms the foundation for constructing causal loop diagrams.

Step 2.2: Create Stock and Flow diagram

Once we have mapped the relationship and dependencies amongst variables, we create the stock and flow diagram through which we simulate the system. To create the stock and flow diagram we specify the relationship between variables by inserting the mathematical equation and values, the data for which we acquire from the SunMoksha team. Based on the qualitative and quantitative data and survey we classify variables as objective variables and decision variables. This allows us to categorize the variables in to simulate the system.
The information that cannot be quantified is incorporated in the framework through Dilemma Triangle Method. While applying Dilemma Triangle Method we use heuristics that are judgements anchored in experiences. This is where the interpretative analysis is executed. The information rather than being made up is anchored with deductive reasoning followed through the steps in the framework. Dilemma Triangle Method forms the foundation for the information that is fed in stock and flow diagram.

Step 2.3: Simulate the system to observe systems behavior

At this stage we simulate the system by conducting various experiments. For example, we vary the amount of tillage and multi cropping in order to understand its effect on the profits incurred and the runoff areas. This step helps us to simulate the system and understand the behavior of the system by analyzing the effects of interaction between variables and on the system.

At this stage we have the interpretations based on the initial Dilemma Triangle construct and evidence based on the system dynamics modelling. We simulate the Kantashol village based on the system dynamics model and critically analyze the behavior. Through this analysis we understand the variables which do not affect the outcome as well as attain insights to identify the problem correctly.

Step 3 Figure 5: Modified Dilemma Triangle Construct

Based on the insights and evidence attained through Step 1 and Step 2, we modify the Dilemma Triangle. This allows us to identify the wicked problem based on interpretations that are based on expert views, and judgements, by inclusion of all the stakeholders as well as on the evidence gathered based on computational simulations. The interpretative analysis is compounded through evidentiary analysis by the aid of System Dynamics.

Accordingly, we have the opportunity to modify the `Focus` and `Issues` through Steps 3.1, 3.2 and 3.3. Further, we construct the `Tension Matrix` for the `Issues` that ties with the Step 3.4. The `Tension Matrix` allows us to find the `Dilemmas` thereby help us frame the wicked problem.

Step 4 Figure 5: Frame the Wicked Problem

After creating the tension matrix, we identify the dilemmas which enable us to frame the wicked problem which is our main objective in this paper.

With the application of framework, we have a perfect reconciliation of interpretative analysis and evidence-based analysis thus ensuring the fidelity of the framing of the wicked problem through human abilities compounded through computational capabilities.

4 RESULTS AND DEMONSTRATION OF THE EFFICACY OF THE PROPOSED FRAMEWORK

In this section we comment on the efficacy of the proposed framework. We discuss the results in three parts, namely, Initial Dilemma Triangle construct, System Dynamics Modelling, and Modified Dilemma Triangle construct.

4.1 Dilemma Triangle Method (Step 1; Figure 5)

a. People

`FOCUS`: To improve the quality of life of people by providing them with adequate nutritious food, water for various purposes, and promote sustainable agroforestry for the sustainable development of the village.

`ISSUES`

1. Lack of agriculture and crop diversification
2. Absence of policies to promote agroforestry and strict government policies to access the forests.
3. Unavailability of water due to lack of facilities, excessive runoff, less rainfall, etc.

b. Planet

`FOCUS`: To preserve forest and its biodiversity, prevent runoff, preserve fertility of the agricultural land, and utilize water resources wisely.

`ISSUES`

1. Excessive tillage for agriculture
2. Overdependence on agroforestry and lack of sustainable agricultural practices.
3. Excessive depletion of water and lack of awareness to maintain the quality of the water.

c. Prosperity

`FOCUS`: To enhance the sources of income for the farmers, to ensure progress in the income of villagers, and to provide reliable and feasible sources of water for varied purposes.

`ISSUES`

1. Excessive runoff due to high tillage resulting in large barren lands in long term.
2. Unawareness of appropriate agricultural practices resulting in high reliance on agroforestry.
3. Unavailability of water due to limited access and an unstable power supply accompanied by unknown wastage of water.

For the initial Dilemma Triangle construct, we define the `Focus` and list the `Issues` encountered to achieve the `Focus` for each `Driver`. This is based on the information from various sources and includes data, experiences, and judgements. Based on the `Issues` and `Focus` for each `Driver`, we create a System Dynamics model and simulate the system to help us understand the interaction between variables.

In this paper we use two types of variables, namely, objective variables and decision variables. We define decision variables as the variables which a designer can assign a value or a set of values to achieve a goal or assess its effect on desired outcome, whereas the variables that represent the objective or goal and measure the effectiveness of the solution are defined as objective variables.

We assess the effect of decision variables on objective variables through System Dynamics.

Based on the information gained, we recognize that for the development to take place we need to increase the disposable income of the villagers without adversely affecting the planet. Thus, in order to ensure this, we demonstrate the utility of the proposed framework by selecting the following objective variables which are of significance to the villagers:

1. Overall Profit
2. Total Runoff Areas

We use following decision variables to assess their effects on above mentioned objective variables:

1. Amount of tillage
2. Multi-cropping

The results presented are specific to the case of the village selected due to the intricacies of various social factors. The main objective of the authors is to demonstrate the efficacy of the proposed framework in order to provide decision support for a designer to identify variables that impact the outcome of a wicked problem which has a plethora of variables under consideration.

This helps us to identify the core of the problem and frame the wicked problems with maximum fidelity. The levels of decision variables are kept as per the judgements and experiences of the authors and may vary for every case. We have simulated the system multiple times to understand the system's behavior and interaction between variables in order to make decisions on the levels of decision variables to assess profit and total runoff areas.

4.2 System Dynamics – Results and Analysis (Step 2; Figure 5)

Values of Input Variables to System Dynamics Model (Data Obtained from SunMoksha Pvt. Ltd.) are presented in Table 1.

The stock and flow diagram of the System Dynamics model is shown in Figure 6. We simulate the system in order to analyze the interaction between variables. We change the magnitude/level of the decision variables in order to understand the effects of each decision variable on the objective variables. We keep the total area available as the highest value considering that we have the entire area for utilization.

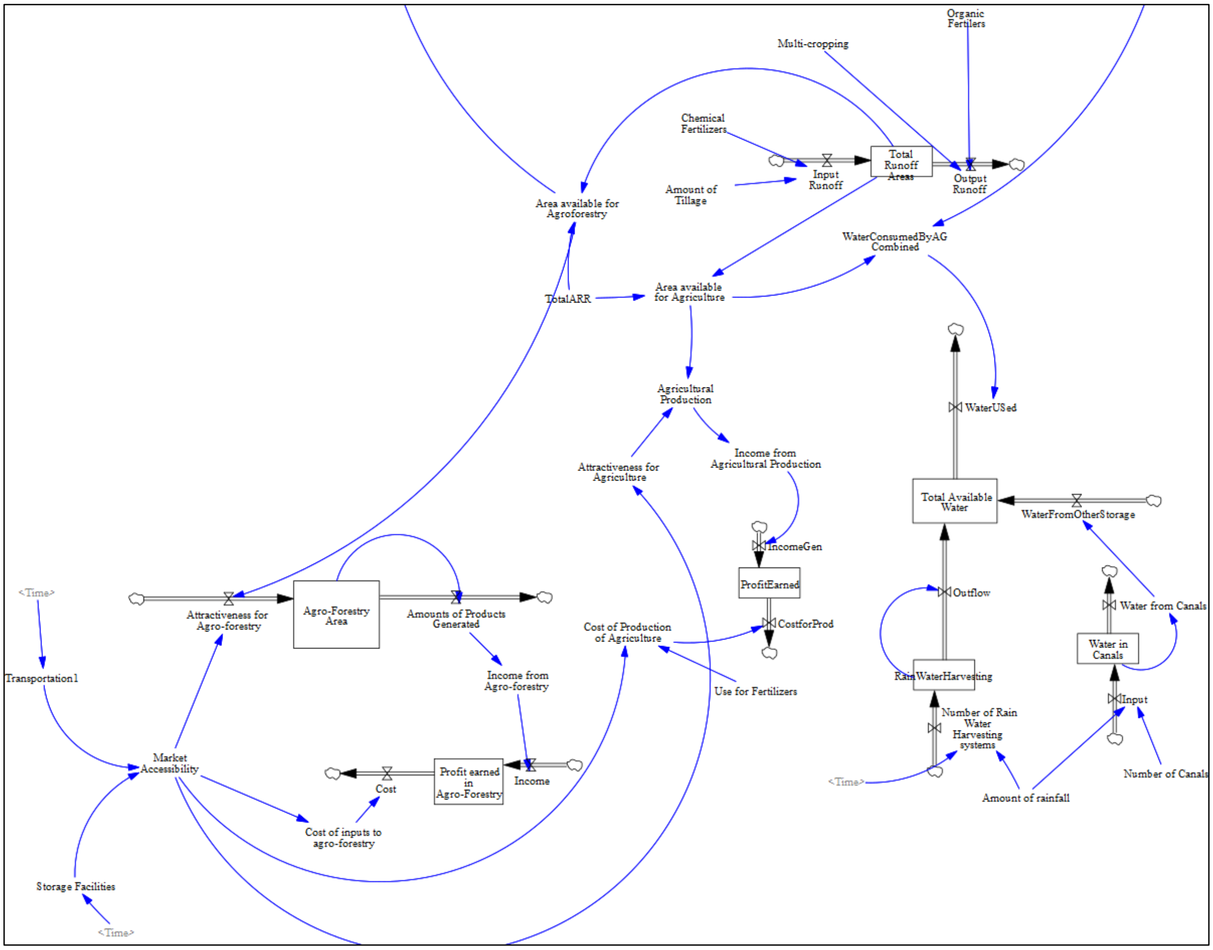

FIGURE 6: STOCK AND FLOW DIAGRAM OF THE KANTASHOL VILLAGE

The control volume is defined by the thematic areas which a designer selects during the Step 1 of the framework. With the thematic areas defined (in our case Forestry, Agriculture, and Water) we define the external boundaries of the control system. The drivers for these thematic areas enable a designer to mark the internal boundaries of the control volume. The consensus on this decision anchors with the experiences and judgements taken during interpretive analysis through Dilemma Triangle Method. While framing wicked problems we do not model the uncertainties, instead observe, and analyze them through simulation of systems. This analysis is then used to make modifications by iterating through the Dilemma Triangle Method and System Dynamics model to frame wicked problems. The insights gleaned through the simulations can then be utilized to synthesize information and mitigate uncertainties to identify the correct size of the problem, concentrate on core of the wickedness subsequently aiding in framing the wicked problems.

4.2.1 Results of System Dynamics Modelling

We initially present the effect of amount of tillage on profit earned and the total runoff areas in Figure 7 and Figure 8. The effect of multi cropping on profit earned and total runoff areas is presented in Figure 9 and Figure 10. The results presented are with low tillage, medium tillage, and high tillage. We keep the value of multi-cropping and the rest of the variables at medium level.

While considering the multi cropping decision variable, we consider the maximum tillage being done in order to be sure that the effect of multi cropping overcomes tillage. We consider two independent variables in the System Dynamics model. The first being amount of tillage and the second being the multi cropping. We assess the effects of these variables on two objective variables, namely, the total profit earned and total runoff areas.

TABLE 1: VALUES FOR INPUT VARIABLES OF THE SYSTEM DYNAMICS MODEL

Input Parameter	Value
Storage Parameter	6 facilities
Transportation	50 vehicles
Amount of Tillage	5000 acres
Cost of chemical fertilizer	310 rupees per acre
Cost of organic fertilizers	150 rupees per acre
Multi-cropping	Normal – 2.5 crops/year – (Variable)
Number of post processing equipment	50 machines
Irrigation cost	5000 rupees per acre
Animal Labor Cost	33 rupees per acre
Cost of Seeds	2000 rupees per acre
Manure cost	150 rupees per acre
Human Labor Cost	5000 rupees per acre
Electricity cost	181 rupees per acre
Diesel Cost	520 rupees per acre
Total Area	20000 acres
Number of canals	5 canals
Amount of rainfall per month	1800 mm per annum
Number of Rain Water Harvesting systems	10 systems

Initially we simulate the system by changing the level of amount of tillage. We consider three levels/cases. One when no tillage is done, another when we simulate moderate tillage and the third with high levels of tillage. As seen through Figure 7, the amount of tillage does not drastically affect the overall profits. The profits remain relatively equal for all the levels of tillage. Thus, the progress of the village does not hamper due to the amount of tillage. However, when we assess the effects of the amount of tillage on the runoff areas, we find that the higher the amount of tillage the larger are the runoff areas.

Runoff is a deleterious factor for the productivity of the agricultural land in the long term. Moreover, the soil loses its fertility which affects Planet. Larger run-off areas results in the decrease in the level of water absorption levels in the soil. To avoid any bias in the results, we maintain other factors at their moderate level during the simulation to analyze the system behavior with respect to change in the quantity of tillage. With the results as shown in Figure 7 and Figure 8, it is evident that the amount of tillage has a significant impact on the total run off areas. Further, in order to assess the impact of multi-cropping on the entire system model, we simulate the system by changing the intensity of the levels of multi-cropping. We assess the impact of change in multi cropping on two factors, namely, the 'overall profit' and the 'total runoff'. The results are presented in Figure 9 and Figure 10.

Analyzing the behavior of the simulated system, we observed that with the increase in multi-cropping there is an increase in the overall profit. Further, on comparing Figure 7 and Figure 9 we observe that the magnitude of decrease in profit due to high tillage is less than that of the magnitude of increase in profits by increasing the levels of multi cropping.

The effect of multi-cropping on runoff areas is observed through the results presented in Figure 10. With increase in the multi cropping, the runoff areas decreases. While simulating the system for multi cropping decision variable we keep the levels of amount of tillage at the highest levels in order to confirm the efficacy of multi cropping for increase in profits and decrease in runoff areas. Through the behavior of the simulated systems, we come to the following conclusions with respect to the decision variables and the objective variables as shown in Table 2. The effect of interaction between decision variables and objective variables considered to demonstrate the framework is summarized in Table 2.

TABLE 2: EFFECT OF DECISION VARIABLES ON OBJECTIVE VARIABLE

Decision Variables	**Objective Variables**	
	Overall Profit	Total Run off areas
Amount of Tillage (↑)	Slightly decreases	Increases considerably
Multi Cropping (↑)	Increases	Decreases considerably

With the results obtained by simulating the system and the explanation provided we identify that the multi-cropping decision variable impacts the outcome. This helps us to identify the core of the problem by eliminating the amount of tillage decision variable. With the results through systems dynamics and the justification provided above we assert that multi-cropping is a significant decision variable while amount of tillage, though of interest to us is not of significance to the model and, thus we eliminate it. Through this we identify the correct size of the problem by identifying the variables which have significant impact on the model/outcome. The utility of this framework comes along with the framing of the wicked problem through evidence based structured process by converting heuristics into insights.

Framing the problem has great significance in order to get robust solutions especially when dealing with wicked socio-economic-technical problems that involve many variables (quantitative and qualitative) that need to be dealt with. Problem framing requires correctly identifying the problem by simulating the system in order to understand its behavior with respect to the variables of interest. In order to model a system and arrive at robust solutions it becomes important to initially frame the wicked problems with high fidelity. The efficacy of the solutions proposed for wicked problems depends on how well the problem is framed.

To achieve this, it becomes important to gain insight on variables which affect the problem to identify the core of the problem where wickedness lies so that it is modelled to provide decision support to the decision makers. This allows us to redefine the `Focus` and `Issues` in the Dilemma Triangle Method in order to understand the exact problem and frame it by revisiting the initial Dilemma Triangle construct (Step 1; Figure 5) that we developed in the initial stages of the framework. Further, we modify the Dilemma Triangle constructed in the initial phase in order to enhance it with the insights gained on the interaction between variables through the behavior of the simulated system.

4.3 Modified Dilemma Triangle (Step 3; Figure 5)

After gaining insights of behavior of the simulated system through System Dynamics as shown in Step 2 of the framework presented in Figure 5, we utilize those insights to modify the Dilemma Triangle in order to frame the wicked problem. These insights are discussed in the Section 4.2.1

The `Drivers` of the Dilemma Triangle remain the same as before: People, Planet and Prosperity. We modify the `Focus` (if required) and `Issues` (as required) based on the results of system dynamics model. We convert heuristics into insights to frame a wicked problem through the integration of evidentiary and interpretative analysis.

a. People

`FOCUS`: To improve the quality of life of people by providing them adequate nutritious food, water for various purposes, and promote sustainable agroforestry for the sustainable development of the village.

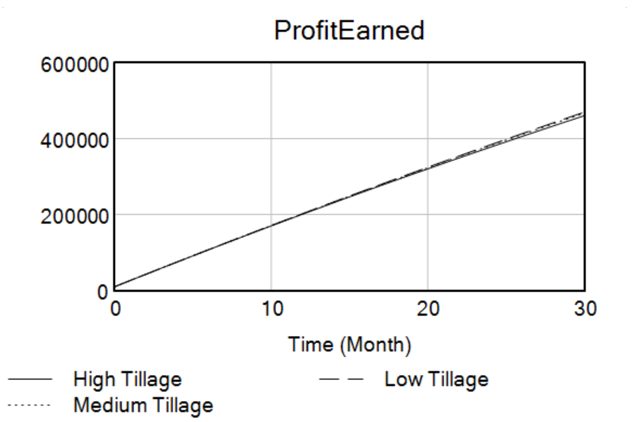

FIGURE 7: EFFECT OF AMOUNT OF TILLAGE ON PROFIT EARNED

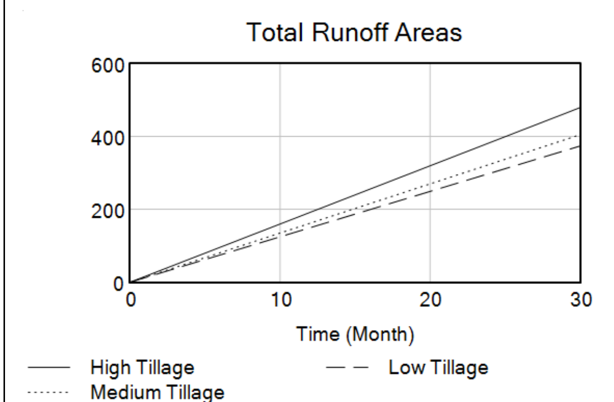

FIGURE 8: EFFECT OF AMOUNT OF TILLAGE ON TOTAL RUN OFF AREAS

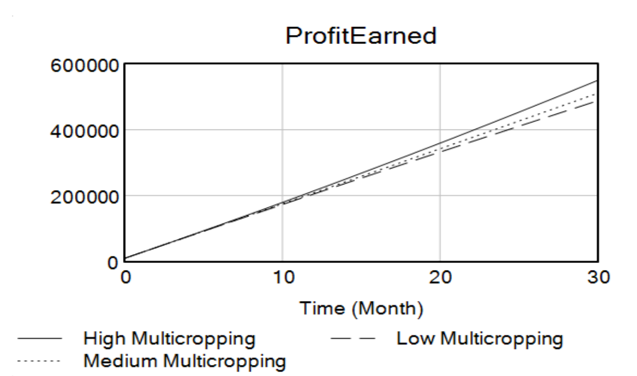

FIGURE 9: EFFECT OF MULTI CROPPING ON PROFIT EARNED

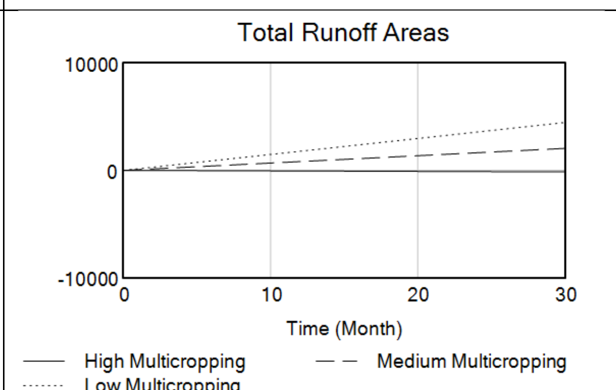

FIGURE 10: EFFECT OF MULTI CROPPING ON TOTAL RUN OFF AREAS

ISSUES

1. Lack of crop diversification and multi-cropping practices in agriculture leading to limited production of nutritious food.
2. Absence of policies to promote agroforestry and strict government policies to access the forests.
3. Unavailability of water due to lack of facilities and improper management in agricultural practices.

b. Planet

FOCUS: To preserve forest and its biodiversity, prevent runoff, preserve fertility of the agricultural land, and utilize water resources wisely.

ISSUES

1. Lack of multi-cropping practices in agriculture contributes to the soil losing its fertility and restricting water to be soaked in the ground leading to the unavailability and depletion of ground water in a village.
2. Overdependence on agroforestry and lack of sustainable agricultural practices.
3. Excessive depletion of water due to mono cropping in agriculture requiring high tillage which enables the soil to lose its fertility.

c. Prosperity

FOCUS: To enhance the disposal income for the farmers, to ensure progress in the income of villagers, and to provide reliable and feasible sources of water for varied purposes.

ISSUES

1. Lack of multi-cropping practices in agriculture. Monocropping results in higher tillage of land which affects the water holding capacity of the soil as well as degrading its fertility.
2. Excessive use of chemical fertilizers to enhance the production in mono cropping resulting in degradation of land in long terms and thus affecting prosperity in long term.
3. Unavailability of water due to limited access and unstable power supply accompanied by prevailing monocropping practices leading to affect the quality of soil and water holding capacity of soil.

With the modified `Focus` and `Issues` in the dilemma triangle we now proceed with the further steps of dilemma triangle method. The `Tension Matrix` is shown in Table 3. In the context of `Tension Matrix` we enumerate Tensions (which are denoted by 'T' in Table 3) to demonstrate the framework and then proceed to find dilemmas which helps a designer frame the problem through the proposed framework.

The efficacy of the framework is observed from the `Dilemmas` identified. The `Dilemmas` are presented in Table 4. We identify the correct problem and the associated `Dilemmas` using insights gained from system behavior through system dynamics. For example, instead of concentrating on the amount of tillage to prevent runoff areas which was initially considered by most of the stakeholders, we could reframe it through identifying the correct alternatives by studying its interaction with other variables. Agriculture requires tillage and thus taking steps to stop it affects the agriculture adversely.

We know that excessive tillage causes increases runoff areas which hampers the water absorbing capacity of the soil Through the framework, we understand that it is the agricultural practices which are more important to `Focus` than emphasizing directly on stopping tillage which is neither a viable solution knowing its necessity in agriculture. The dilemmas which anchor with framing the wicked problem are presented in Table 4. Further, knowing its interaction with other variables we also eliminate the variable in modelling the system further to identify the dilemmas/frame the problems. This demonstrates the efficacy of the framework provided. Thus, through the proposed framework, a designer can:

1. Convert heuristics into insights to frame a wicked problem through the integration of evidentiary and interpretative analysis.
2. Understand the interaction between variables through behavior of the simulated system by the virtue of System Dynamics.
3. Identify the correct size of the problem by eliminating the variables which do not impact the outcome/model and are not relevant to the wicked problem.

These three aspects together help in efficient framing of the wicked problem.

In this paper we account for the key issues that are italicized in the ten characteristics of wicked problem recognized by Rittel and Weber [6] which is discussed in Section 1. We summarize how we address these key issues by the application of our framework in Table 5.

5. DISCUSSION

In this section we comment on the bottlenecks, verification of the framework as well as list a few limitations observed while applying it to frame a wicked problem.

The bottlenecks in the framework include undertaking interpretive analysis through Dilemma Triangle Method. This requires judgement and heuristics to be incorporated at the initial stage of the analysis. This includes exploring and interpreting data from the perspective of individuals which requires a designer to have experience with Dilemma Triangle Method. Further, the iteration from System Dynamics model back to Dilemma Triangle Method requires analysis of interaction of variables to modify the initial exercise of the Dilemma Triangle Method. This requires a designer to move back and forth and iterate in order to identify the wickedness of the problem.

TABLE 3: TENSION MATRIX *(T – Tension, D – Dependent)*

	Lack of multi cropping	Absence of policies to promote agroforestry/Strict policies to access forest	Unavailability of water – improper agricultural practices	Limited production	Overdependence on agroforestry	Excessive depletion of water	Higher tillage	Excessive chemical fertilisers	Unavailability of water
Higher tillage					T1	D			
Excessive chemical fertilisers	T2	T3		T4	T5		T6		
Unavailability of water			T7		T8	T9	T10		
Limited production	D	D	T 11			T12	T13	T14	T15
Overdependence on agroforestry	D	T16	T17				T18		
Excessive depletion of water									
Lack of multi cropping			D						
Absence of policies to promote agroforestry/Strict policies to access forest			T19						
Unavailability of water – improper agricultural practices									

TABLE 4: DESCRIPTION OF DILEMMAS

Sr. No.	Dilemma- Framing Wicked Problems	Dilemma arrived from	Justification
1	How can we promote multi-cropping by reducing the use of chemical fertilizers and promoting organic fertilizers by ensuring decent production levels?	Tensions 2 and 4	Through the systems behavior it is evident that multi-cropping has a significant role to play for the planet and prosperity of the village. Further, through simulations we could realize that organic fertilizers play an important role in the development of planet. Monocropping comes with excessive use of chemical fertilizers (to increase production and gain profits) to match with the nutrients that soil has lost. Thus, it is important to promote multi-cropping to reduce the use of chemical fertilizers whilst ensuring that the production through agriculture is decent.
2	How can we ensure higher production and progress of the village by promoting eco-friendly methods of agriculture without exploiting the available water?	Tensions 4 and 11	The use of fertilizers in mono cropping not only affects the overall progress of the village but also degrades the planet. However, villagers are unaware about efficient and proper methods of agriculture. With the introduction of new methods there are high chances of exploitation of natural resources like water. Thus, it is very important to ensure that we preserve the planet and also help people and ensure prosperity by adopting eco-friendly methods of agriculture.
3	How can we reduce the overdependence of farmers on agroforestry and enable them to get decent production and sources of production through agricultural practices without making them overly relied on chemical fertilisers?	T1, T5, T15, T17	Reducing overdependence of agroforestry comes with excessive agriculture. Increased participation in agriculture results in exploitation of resources and degradation of planet due to excessive monocropping, high tillage, improper use of water, etc. Excessive monocropping and high tillage results in loosening of the soils water holding capacity which results in waste of available water. Thus, it is important to reduce the overdependence of farmers whilst also ensuring that their participation in agriculture does not harms the planet.

Table 5: SUMMARY OF KEY ISSUES ADDRESSED	
Wicked Problem Characteristics	Contextualization
There is no definitive formulation of wicked problems. They are difficult to frame.	The framework provides a holistic approach to frame and identify correct size of wicked problems.
Wicked problems have no stopping rule.	We provide an opportunity to iterate through the framework. This augments the combination of interpretive and evidentiary analysis to understand the nature of the problem. This allows a designer to do better with every iteration until reaching a certain point. By iterating, a designer can identify the finer details and relation between variables which result in appropriate framing of wicked problem.
Solutions to wicked problems are not true or false, but good or bad.	Through the combination of Dilemma Triangle Method and System Dynamics we approach towards getting better insights for every iteration we have, enabling us to frame problems correctly which is the first step to approach better solutions.
There is no immediate and no ultimate test of a good solution to a wicked problem.	Through the framework we provide an opportunity for a designer to involve human intelligence and cognitive abilities which augment computational capabilities in order to enhance the fidelity of framing wicked problems. Through this we give a designer a frame to enhance test-ability.
There are numerous explanations for a wicked problem.	With this framework the problem becomes concrete for the a designer to identify the focus without making foregone conclusions about prior explanations.
The planner has no right to be wrong.	Through the framework we provide an opportunity for the a designer to analyze the dilemmas and the causal relationships between different elements (variables). Through the framework a designer can carry analysis to interpret and compare a variety of conflicting scenarios resulting in improvement of the characteristics and 'corroboration' of results with the wickedness of the problem. Thus, with this framework we provide an opportunity to 'improve' rather than aiming to find the truth.

Verification of the Proposed Framework: In Steps 1, 2, and 3 as shown in Figure 5, and further discussed in detail in Section 4, we gain input from the SunMoksha team of experts. After demonstrating the efficacy of the framework for the test problem, we confirm the results obtained through the proposed framework with the experts in SunMoksha Team as well as the villagers. We are informed that more such insights can be gained by modifying the thematic areas and modifying the System Dynamics model. The verification of the proposed framework comes through multiple trials and experimental simulations run by the authors. These experimental trials are carried out with multiple scenarios and verified accordingly in accordance with the SunMoksha team and the authors. The validation of the framework is yet to be carried out.

Limitations of the Proposed Framework: The framework is based on the assumption that the Dilemma Triangle Method is executed rationally without any bias. Further, we assume that all the stakeholders act rationally which ideally should be the case, however, it might not happen. Further, the evolution of variables is not considered in this work, and we assume that variables are proportional with respect to time. This brings us with the following limitations:

i. The efficacy of the framework depends on the expertise, judgement, and interpretations of humans. Inclusion of bias by human cognitive capabilities make the results obtained through the framework futile and it negatively impacts the framing of wicked problems.
ii. System Dynamics used to simulate the system through *predefined data*.

What is the impact of a predefined set of rules and data? When we create a model (even at an initial level) we are explicitly defining the relations between different variables. For example, in stock and flow diagram we specify the causal relations between variables and define it through equations, which is essentially training the model on how it should behave. This implies that we are training the variables on how they should behave with any change which is done through simulations or changing the equations.

6. CLOSING REMARKS

"How can a designer frame a wicked problem and identify the variables that can be used to design a socio-economic-technical system?"

In response to the question, in this paper, we propose a framework to frame wicked problems through interpretative analysis by utilizing Dilemma Triangle Method and evidentiary analysis through the System Dynamics modelling. With the proposed framework, we provide an opportunity to a designer to frame any wicked problem. The framework is designed to convert heuristics that a designer has in the initial phase, to insights by the analysis of interaction between variables through systems simulation by using System Dynamics. The framework consists of three stages, the first being the Dilemma Triangle Method, (Step 1; Figure 5) which is used to identify the `Drivers` and define the `Focus` of these `Drivers`. At this stage we do not identify the dilemmas. The second stage (Step 2; Figure 5) includes analyzing the system behavior and the variable interaction through System Dynamics. Through this stage we get insights on behavior of the simulated system and the interaction between variables. This analysis enables us to identify variables which impact wicked problems and thus identify the correct size of the problem by identifying its core. Further, the third stage (Step 3; Figure 5) is revisiting the Dilemma Triangle constructed in Step 1 and modifying it with the insights gained through System Dynamics. This allows us to modify the tensions based on insights gained through the behavior of the simulated system and then identify dilemmas to frame wicked problems.

To illustrate the efficacy of the framework we use an example of Kantashol village, a socio-economic-technical system, which is in Jharkhand, India. In Kantashol, villagers are overdependent on forestry for their livelihood and the practice of agriculture is limited due to multiple reasons including lack of water, insufficient yields due to improper methods of agriculture etc. Villagers have overexploited the ground water, and there is excessive runoff due to excessive tillage for agriculture. We see that there are three thematic areas that need to be considered, namely; Forestry, Agriculture, and Water. We classify this as a wicked problem due to the incomplete and conflicting information available, conflicting perspectives of the villagers in Kantashol, multiple explanations of the existing problems in the village, and the existence of multiple tensions between the `Drivers`. Initially we attain heuristics from the expertise of the SunMoksha team and experiences of the villagers. We define `Drivers`, `Focus` for each `Driver`, and `Issues` for each `Drivers` through the heuristics attained. Further, we create a System Dynamics model to convert the heuristics into insight through the qualitative and quantitative data from SunMoksha team. The results we get from System Dynamics model help us to gather insight on the interaction between variables. This is demonstrated in Section 5 by eliminating the 'amount of tillage' decision variable by showing its interaction with 'multi-cropping' decision variable. We demonstrate through the System Dynamics modelling that 'multi-cropping' is a significant variable that affects the problem, and which suppresses the negative effects caused by 'amount of tillage'. Moreover, we demonstrate that its effect on the objective variables, namely, 'total runoff areas' and 'overall profit' is insignificant in comparison to 'multi-cropping' variable. Thus, we identify the variables which impact the core of the problem leading us to gain insights on the correct size of the problem. Thus, through the proposed framework, a designer can:

i. Convert heuristics into insights to frame a wicked problem through the integration of evidentiary and interpretative analysis.
ii. Understand the interaction between variables through behavior of the simulated system by the virtue of System Dynamics.
iii. Identify the correct size of the problem by eliminating the variables which do not impact the outcome/model, are not relevant to the wicked problem, or not under a designer's control.

The utility of the proposed framework for framing a wicked problem are:

i. Enhancing the synergy between human-computer interaction by allowing human-in-the -loop to enhance framing of the wicked problem through computational capabilities and human abilities.
ii. Enables a designer to convert the heuristics into insights through a structured process.
iii. Perfect integration of interpretative and evidentiary analysis to frame the wicked problems which forms the fundamental step of modelling a public policy.

The proposed framework can be extended in various domains to frame wicked problems. In the following discussion we expand the possibility of application of the proposed framework in different research areas for varied problems. Problem (i) and (ii) are presented by NSF-NASA in a workshop with an objective to provide the context to a designer on wicked problems and extreme design problems whereas Problem (iii) is the one that authors are working on.

i. *Revitalizing Rural Communities that Depend on One Industry*

   Many regions in industrialized countries:
   - Remain isolated and lack access to goods, services, and resources that are vital to thriving.
   - Often suffer from single-industry economic dependencies that limit growth opportunities and upward, both individually and regionally.

   Goal: For rural communities to thrive and become resilient outside of single industry infrastructure.

ii. *Democratizing Medical Supply Delivery*
   - Current medical supply transport is plagued by losses, including a relatively high temperature excursion rate.

- Delivery includes a diverse supply chain.
- Access to medical supplies is limited in some communities in the U.S. and abroad.
- Current U.S. regulatory and liability frameworks do not account for medical transport by non-traditional vehicles such as a drone.

iii. *Environmental Justice in Oklahoma City*

Urban atmospheric pollution is driven by policy decisions negotiated by competing interests including local and regional governments, industry, and citizen's groups. Policy goals may greatly impact exposure to pollutants harmful to health and wellbeing, exemplified in extrema by historic redlining of minority groups in dense clusters near industrial emitters, generating urban canyon effects which further trap already significant pollutants with known health impacts. As the environmental sensor revolution quietly takes place in our urban centers, an opportunity arises to inject cyber system infrastructure data into extant social decision-making frameworks which shape our physical future by helping planners make better informed design decisions for uncertain policy futures. We have identified a sample region in Oklahoma City which meets the historic context above and presents a growth opportunity for a prototype framework to integrate with current policy-`Drivers`, including growth of sensing infrastructure in the region.

Wicked problems exist in every research area. The preceding are some examples in which the framework for framing wicked problems using evidentiary and interpretive analysis may be used by a designer. The authors have provided an opportunity to a designer to frame wicked problems through evidentiary and interpretative analysis by involving human-in-the-loop and identifying correct size of the problem and the variables which impact the wickedness of wicked problems.

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