

Solving Poverty using Ontology

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Abstract: This paper presents an ontology-based approach to address poverty. Poverty has been one of the serious societal problems that the world is facing in recent times. The approach has been modeled in such a way that it can be used to solve any other wicked problem of the society as well including corruption, bad governance, traffic management, poor education and many others. The causes of the said problem were modeled at different level of granularity. The proposed model also incorporates various different ways of addressing poverty by addressing possible causes of poverty. The presented scheme of using an ontology to address the wicked problem has the inferencing capability also to infer the indirect causes of poverty.

1 INTRODUCTION

The World Bank Organization describes poverty in this way:

"Poverty is hunger. Poverty is lack of shelter. Poverty is being sick and not being able to see a doctor. Poverty is not having access to school and not knowing how to read. Poverty is not having a job, is fear for the future, living one day at a time.

Poverty has many faces, changing from place to place and across time, and has been described in many ways. Most often, poverty is a situation people want to escape. So poverty is a call to action – for the poor and the wealthy alike – a call to change the world so that many more may have enough to eat, adequate shelter, access to education and health, protection from violence, and a voice in what happens in their communities."

The problem of Poverty is well known across the globe. Every country is facing this issue. However, the extent to which poverty prevails in the society is different in different parts of the globe. There is no one ultimate cause of poverty. The cause of poverty varies from location to location. Living a poor life in USA is different from the life of poverty in a third world country such as Pakistan or Bangladesh.

We believe that in order to address the issue of poverty, we need to model poverty as a system of causes and possible solutions to these causes. This paper describes our systematic approach based on Ontology, developed to address the causes of poverty. The causes which have been considered in this paper

are based on our observation of livelihood in Pakistan.

There are different measures to capture the poverty in a country. The most commonly used measure is a Multidimensional Poverty Index (MPI). The multidimensional poverty index is used to measure the severe deprivations that the individual experiences with respect to the living standard, education and health services. Multiple variables are used to capture the quality of education, health and standard of living in a country.

According to the survey report on Multidimensional poverty published by the ministry of planning, development and reform in Pakistan¹, the multidimensional poverty index of Pakistan is 0.197. The MPI showed that the 38.8% of the population of Pakistan is poor. The statistics mentioned in the report showed that the proportion of poor people living in urban areas is significantly lower than the ratio of poor people living in rural areas of Pakistan. Education deprivation in Pakistan made the greatest contribution to national poverty, followed by living standards and health services deprivation.

The main contributions of this research are as follows:

1. The development of an ontology aiming to model wicked problems.
2. The instantiation of the developed ontology to capture the global issue of Poverty.

¹http://www.pk.undp.org/content/pakistan/en/home/library/hiv_aids/Multidimensional-Poverty-in-Pakistan.html

This paper presents the ontological solution to address the issue of poverty. The ways presented in this paper are further discussed in the Discussion section using the leverage points proposed by Donella H. Meadows (Meadows et al., 1997). Donella H. Meadows discussed leverage points to intervene in a system. Nine different leverage points were presented which are as follows:

1. **Numbers (Subsidies, Taxes, Standards):** Numbers were considered as the least important leverage point.
2. **Material Stocks and Flows:** The stocks and flows effect the system operations.
3. **Regulating Negative Feedback Loops:** Negative feedback loops are an important leverage point. Systems' performance can be improved by regulating negative feedback loops.
4. **Driving Positive Feedback Loops:** Positive feedback loops determine development and destructions in systems.
5. **Information Flows:** The information flow in the system can be considered as another important leverage point for the policy makers and company strategist. It is important to identify the missing information correctly at the right time.
6. **The Rules of the System:** Rules of the system includes incentives and constraints applied to the system. If someone wants to understand the malfunctions of systems, then he should try to identify where in the system some rule is broken.
7. **The Power of Self-organization:** Self-organization refers to the change in any aspect of a system lower on this list, such as addition or removal of the new physical structure, adding or deleting negative or positive loops or information flows or rules.
8. **The Goals of the System:** The goal of the system is an important leverage point. As everything on this list is forced to conform to system goals.
9. **The Mindset or Paradigm out of which the Goals, Rules, Feedback Structure Arise:** Paradigms are the bases of systems. Goals, information flows, feedbacks, stocks, flows emerge from the paradigm. People who manage to intervene in systems at the level of paradigm hit a leverage point that completely changes systems.

The rest of the paper is organized as follows. Section 2 describes the related work. Section 3 defines poverty as the wicked societal problem and the characteristics of the wicked problem. Section 4 presents the methodology. Section 5 includes the discussion and finally, Section 6 concludes this paper.

2 RELATED WORK

The literature review section is subdivided into two subsections. In the first subsection, we described the application of ontology. In the second subsection, the approaches proposed for addressing poverty are described.

2.1 Ontology

The use of ontology to model complex systems has been widely studied in literature. This section presents the brief overview of the work done on ontology by various researchers. L.C Van Ruijven (Van Ruijven, 2013) discussed the interoperability issues faced in capital facilities industry due to the highly distributed nature of such industries. It was highlighted that the lack of proper communication and inadequate exchange of information within projects were the main reason of project failure. An ontology-based approach was proposed for managing various industrial processes. The proposed ontology is currently used in major infrastructure projects in the Netherlands. The ontology was based on the simplification of ISO 15926. The implementation of the presented ontology was done using the information management tool Relatics.

H.J Happel (Happel and Seedorf, 2006) discussed various applications of ontologies in software engineering. The paper presented a framework for classifying usage of ontologies in software engineering. The concrete approaches for using ontology in the software engineering life cycle was discussed. The use of ontology in each phase of development cycle improves the communication and information management. It enables developers to share a common vocabulary for communication.

Eric C. Honour (Honour and Valerdi, 2006) discussed the need for ontology in designing systems. An ongoing project Systems Engineering Return on Investment (SE-ROI) aims to collect empirical information to understand how systems engineering methods relate to program success (cost, schedule, and technical terms). The purpose of the project is to convert ontology into a methodology for measure return on investment of software engineering projects. The paper highlighted the fact that one of the greatest challenges in quantifying systems engineering is the lack of a shared conceptualization. The challenge can be overcome through the use of well-defined ontology for software systems.

Jonathan DiLeo et al. (DiLeo et al., 2006) extended the approach developed earlier for analyzing, designing, and developing multiagent systems, called

Multiagent Systems Engineering (MaSE). The presented approach extends MaSE to include the use of ontologies for information domain specification. The authors highlighted the fact that though many methodologies have been developed for engineering multi-agent systems, however, these approaches do not sufficiently address the need of information domain system. The extensions allow the designer to specify information flow by using objects from the ontology as parameters in agent conversations. The ontologies were used to specify the information domain of a multiagent system. The agents in the system interact by passing messages and these messages frequently involve passing parameters.

Humberto L. O. Dalpra et al. (Dalpra et al., 2015) proposed an approach based on ontology for the software process improvement. The paper discussed that the process improvement can be achieved by analyzing process data execution with an approach called PROV-Process, which uses a layer for storing process provenance and an ontology based on PROV-O. The use of ontology enables software engineering to detect the activities that influenced the generation of other activities. Furthermore, we can identify agents that could be associated with the solution of the deployment task, considering that they already handled the artifacts involved in this task in any other execution of the process.

Kohli et. al (Kohli et al., 2012) presented the ontology of slums for classifying images. They proposed an ontological framework to analyze and classify slums. The ontology contained well-defined terms that can be used to understand the relationship between image and slum characteristics.

2.2 Poverty

Rodríguez-Pose et al. (Rodríguez-Pose and Hardy, 2015) addressed the problem of poverty using rural development methodology. The political, social and economic changes to rural areas impact the rural development. Their research suggested that the agricultural and non-agricultural development methods can be used to alleviate the problem of poverty.

Yang Zhou et. al (Zhou et al., 2018) studied the problem of poverty in China. The research studied the impact of land policy innovations in alleviating poverty from China. Another study on rural poverty in China was conducted by Yansui Liu (Liu et al., 2017). The study examined the spatial distribution characteristics of poverty in rural China.

Abdul Hameed et. al (Hameed et al., 2016) presented their study on poverty in Pakistan. According to this study, 59% population of Pakistan is poor. The

author suggested that the rural poverty can be eliminated through education, improved living standards, and income growth.

Sajid Pervez (Pervez, 2016) described the role of education in addressing poverty. Their results showed that the education has a significant impact on improving the employment status of people which helps in reducing poverty from the country.

Alvarez et. al (Alvarez et al., 2015) discussed five major ways of poverty alleviation which includes micro-finance, social entrepreneurship, foreign aid, the base of the pyramid initiatives and the property rights. Each of these measures was critically reviewed and limitations were identified. Despite these five majors, their paper concluded that international industrialization can have a far more promising impact on the poverty alleviation.

3 POVERTY - WICKED PROBLEM

Rittel et al. (Rittel and Webber, 1973) discussed certain characteristics of wicked problem. The paper discussed that most of the real-life problems are wicked problems, unlike the problems we study in various domains such as mathematics, physics and science and engineering. Wicked problems are the problems which are poorly defined. The paper explained various characteristics of such problems which are as follows:

- i The fundamental property of wicked problems is that there is no complete formulation possible for such problems. We are unable to propose a formulation that covers all the variables or factors impacting a wicked problem.
- ii Wicked problems have no stopping rule because there is no criteria for sufficiently understanding the underlying problem. Usually, people stopped working on such problems not because the work gets completed but because either the resources get exhausted or the solution obtained so far is sufficient for the time being.
- iii There are no right or wrong solutions to wicked problems, rather we compare the quality of various different solutions of wicked problems with each other to decide which one to adopt.
- iv Another property of wicked problem is that there is no immediate or ultimate test of a solution to wicked problems. Once implemented, consequences can be seen over the period of time.
- v With wicked problems planning, every solution which gets implemented have a consequence on

the society. A cost is involved; therefore, a critical analysis of the solution and the possible consequences is required before the solution gets implemented.

- vi Wicked problems don't have a clearly defined list of all possible solutions
- vii Every wicked problem has a distinguishing characteristic which implies that the solution to one wicked problem cannot be applied to another problem.
- viii A wicked problem can be considered as a cause of another wicked problem. We can consider a wicked problem as a network of subproblems which also possess the attributes of a wicked problem.
- ix Wicked problems can be explained using numerous ways. The explanation determines the nature of the proposed solution.

In the light of attributes of a wicked problem discussed above, the issue of poverty can be modeled as a wicked problem. We are unable to formalize all the social variables causing poverty. The reason of this incomplete formalization is due to the cultural dependency of poverty on various social attributes. This leads to consider poverty as a wicked problem. Moreover, there can be various ways to address poverty. However, there is no perfect solution so far to completely eradicate poverty. We can model poverty as a network of other subproblems. This will be discussed in detail in the next section.

4 METHODOLOGY

This section describes the ontology-based approach of modeling poverty. Though the approach discussed here is implemented the problem of *Poverty*, however, it can be adopted to address any wicked problem.

Figure 1 describes the root causes of poverty. It was identified that the root causes also have various sub-causes. Unemployment has various sub-causes expanded on level 3 and level 4 as shown in Figure 2.

After the identification of various causes and sub-causes of Poverty, ontology of Poverty was constructed. Protege was used to construct the ontology.

4.1 Classes

Following classes are defined in the proposed ontology.

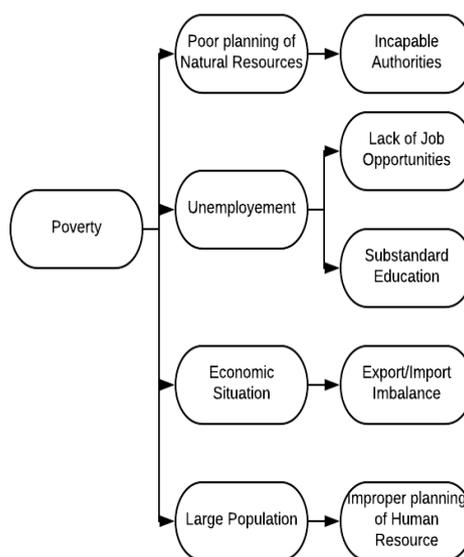


Figure 1: Level 1 and Level 2 causes of Poverty.

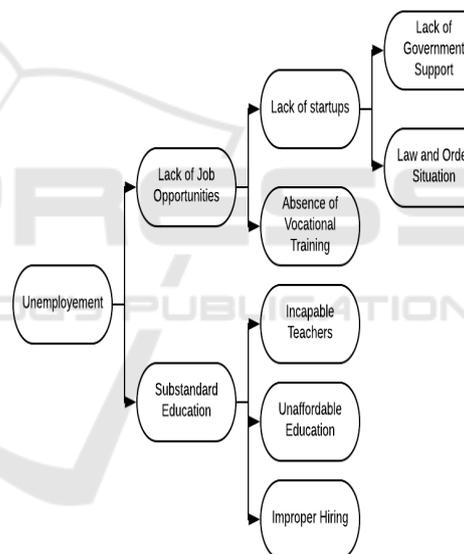


Figure 2: Causes network of Unemployment.

1. **Problem:** The class problem represents the concept of any wicked problem.
2. **Solution:** The class solution represents the concept of the solutions to a wicked problem.

4.2 Instances

4.2.1 Instances of Problem

Following instances are defined for class Problem in the proposed ontology.

- i **Absence of Vocational Training Institutes:** It

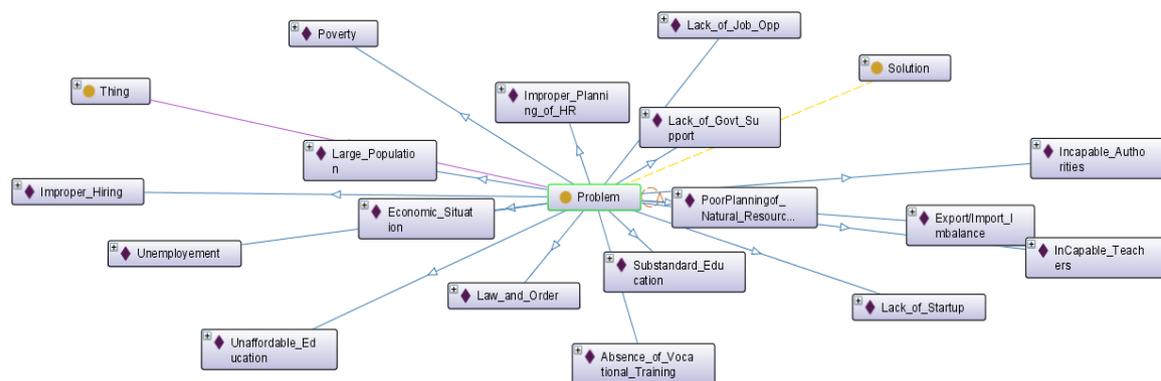


Figure 3: Ontology.

has been observed that there is a lack of vocational training institutes in Pakistan. The lack of vocational training institutes leads to lack of job opportunities.

- ii **Economic Situation:** The economic situation refers to the economic growth of the country. Economic growth of the country greatly influences the poverty ratio. In the proposed ontology, we considered economic situation as a direct cause of poverty.
- iii **Export/Import Imbalance:** The import/export imbalance occurs when the ratio of export is significantly less than the ratio of import. This is considered as a sub-cause of economic situation. If export to import ratio is good then the economic growth will rise, which eventually help us in reducing poverty.
- iv **Improper Hiring:** Improper hiring mechanism of teachers at primary/secondary level of education degrades the quality of education. Due to the low quality education, youth face difficulty in ceasing potential job opportunities. This leads to increase in unemployment ratio which rise the poverty ratio in a country.
- v **Improper Planning of Human Resource:** Unlike developed countries, there is no proper planning department for managing large population in under developed countries. Due to the unplanned growth in population, poverty level rises in a country.
- vi **Incapable Authorities:** Due to the incapability of authorities, the natural resources are not utilized properly for the creation of new job opportunities. This causes increase in poverty.
- vii **Incapable Teachers:** It has been observed that the incapable teachers are one of the cause of sub standard education in Pakistan.
- viii **Lack of Government Support:** At the government level, there is no support for the startups in terms of tax relaxation and funding. This causes lack of startups in Pakistan.
- ix **Lack of Job Opportunities:** One of the major cause of unemployment is the lack of job opportunities.
- x **Lack of Startups:** Lack of job opportunities is due to the lack of startups. The increase in number of startups will provide job opportunities to the youth which will help in addressing unemployment.
- xi **Large Population:** The unplanned growth in population is one of the major cause of poverty.
- xii **Law and Order Situation:** Law and order situation has the direct impact on the business of the country. If the situation is good, then investors will be willing to invest in small businesses/ startups.
- xiii **Poor planning of Natural Resources:** Natural resources are the wealth of any country. The proper utilization of these resources can bring prosperity to the country which ultimately helps in reducing the poverty from the country.
- xiv **Poverty:** Poverty is one of the major problem of the third world countries such as Pakistan.
- xv **Substandard Education:** Substandard education refers to the poor quality of education being provided to the youth of the country. It is one of the major cause of unemployment in the country.
- xvi **Unaffordable Education:** The high quality education is too expensive for the common man of the country.
- xvii **Unemployment:** Unemployment is one of the direct cause of poverty.

4.2.2 Instances of Solution

Following instances are defined for class Solution in the proposed ontology.

- i **Awareness:** Making general public aware of the new job opportunities, vocational and development programs will help in addressing poverty.
- ii **Support of Donors:** The problem of lack of startups due to funding issues can be addressed if the financial support can be attained from the donor organizations.
- iii **Government Support:** If government provides support to small startups in terms of taxation then this will encourage people to start small business which will ultimately help in reducing unemployment.
- iv **Industries:** To solve the problem of export/import imbalance, new industries need to be established.
- v **Personality Development and Training:** If we have more capable teachers then the quality of education can be improved. If teachers are provided with personality development and training programs, they can grow professionally.
- vi **Proper Planning:** Proper planning for utilizing natural resources for the prosperity of the country will solve the problem of poor planning of natural resources.
- vii **Vocational Training:** Vocational training institutes can help in developing skills in the youth so that they can find job according to their skill set. This will help in reducing unemployment in the country.

4.3 Object Properties

To connect problems with solutions, following object properties were defined in the proposed ontology.

1. **Caused by:** The domain of *caused by* is the instance of problem and the range is also an instance of problem. For e.g poverty is caused by unemployment
2. **Solved by:** The domain of *solved by* is the instance of problem and the range is an instance of solution. For e.g lack of startup is solved by donors support
3. **Cause:** This is the inverse of *caused by* property. For e.g unemployment cause poverty

4.4 Data Properties

Data properties are the attributes of the classes. Following data properties were defined in the proposed ontology.

1. **Description:** This defines the description of problem. The domain is the instance of problem and range is the string.
2. **Level:** It is used to represent the level of the problem. The domain is the instance of problem and range is the integer. For e.g Poverty is assigned level 0 and all the primary causes of poverty are assigned level 1.

Figure 3 presents proposed ontology of the poverty.

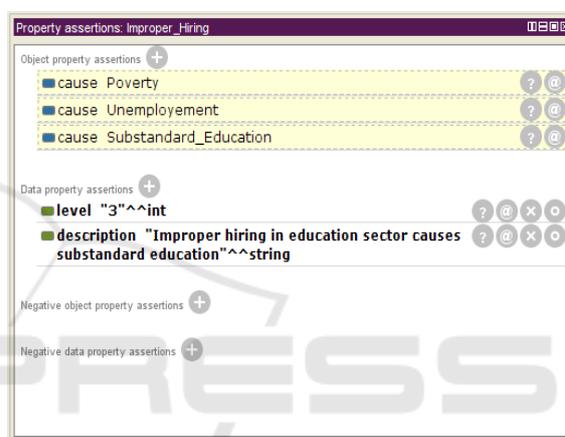


Figure 4: Reasoning through proposed Ontology.

4.5 Reasoning

Reasoning is one of the very powerful feature of ontology. Reasoning enabled us to understand the relationship between various causes of poverty at different level of granularities. As described in Section IV that the symptoms of wicked problem are related to each other, with reasoning we were able to identify these relationships.

Figure 4 shows that the proposed methodology inferred that the cause *Improper Hiring* also causes *Substandard Education*, *Unemployment* and *Poverty*. The inferencing was based on the transitivity of *cause* and *caused by* properties. The instance *Unemployment* is the upper level *Level 1* cause of *Poverty* where as *Substandard Education* was defined as the cause of *Unemployment*. Further, *Improper Hiring* is related to *Substandard Education* through *cause* property.

The reasoning engine inferred that since *Substandard Education* cause *Unemployment* and *Unemployment* cause *Poverty* therefore, the instance *Improper Hiring* is related to *Unemployment* and *Poverty* through *cause* relationship.

5 DISCUSSION

This section discussed the findings of our research work as follows

1. The modeling of a wicked problem *poverty* help us in understanding the various different causes of the root problem and the solutions. Also we were able to model the relationship between these causes and solutions at different level of granularities.
2. The ontology helps us in understanding the holistic view of the problem. The reasoning capability of the proposed ontology also help us in understanding how the causes are indirectly related to each other. For example, causes with level number 3 such as *Improper Hiring mechanism* are indirectly impacting the causes with level less than 3.

To the best of our knowledge, this is the first attempt of modeling poverty using ontology as a modeling tool. As discussed in the literature review section, people have performed economic studies on the issue of poverty.

The leverage points presented in Section I can be used to evaluate the effectiveness of various different solutions proposed in this paper for *poverty*. Below is the description of each of the leverage point that can be applied on the solutions proposed above.

1. **Numbers:** By increasing the number of industries and vocational training institutes, we can address unemployment which will ultimately help in reducing the poverty.
2. **Information Flows:** This is the responsibility of policy makers to collect population statistics regarding poverty such as ratio of population having access to clean water, food, shelter and education.
3. **The Goals of the System:** In order to reduce poverty in a systematic manner, short term and long term goals can be established to evaluate the performance of working bodies.
4. **The Mindset:** The mindset of people can be improved by spreading awareness regarding the poverty and the efforts made to eradicate it. Personality development and training of teachers can also help in improving the quality of education. By improving the quality of education, we can reduce poverty.

The leverage points discussed above will help in improving the quality of proposed solutions and this will ultimately help in the eradication of poverty from the society.

6 CONCLUSION

This research discusses the ontology-based model of poverty where we have shown the relationship between poverty and its causes. The causes were arranged at the different level of granularity. The proposed ontology also incorporates the ways through which we can address the issue poverty.

This paper presented the ontological approach to model the problem of poverty. The proposed approach can help us in modeling any wicked problem. The benefit of using ontology-based approach over other traditional modeling approaches such as Unified Modeling Language(UML) and Entity relationship diagram (ERD) is the reasoning capability of ontology. Through reasoning, we can infer useful insights on the ontology-based model. Reasoning enabled us to understand the interrelationships between various causes of poverty. This understanding can help us to prioritize our solutions while addressing these causes. Furthermore, the solutions proposed for poverty alleviation were analyzed using the leverage points proposed by Meadows (Meadows et al., 1997). In the future, the work can be extended further to enrich the ontology with more details by incorporating other relationships.

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