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Using Participatory Elicitation to Identify Population Needs and Power Structures in Conflict Environments

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ABSTRACT

A methodological approach is reported to produce a context analysis in South Afghanistan under the banner of Do No Harm (DNH). The difficult work environment for locals, development workers and researchers alike is briefly described; and the problem that is supposed to be solved is derived from it, namely how to elicit the needs and requirements of the population. Step by step the reader is guided through the approach proposed and a selection of results is presented that (arguably) demonstrate the usefulness of our ideas for optimal (DNH) project portfolio design.

1 INTRODUCTION

Local communities and development workers bear the risks of development cooperation work in areas experiencing armed conflict. Most such risks emanate from local security conditions as local strongmen, criminals, bandits, paramilitaries, local and national law enforcement forces and armed forces interact with each other and local communities that are prone to extortion, intimidation and outright violence and with development workers who constitute high-value targets.

In such circumstances, prevailing practices of context analysis, performance monitoring, progress evaluation, impact assessment and other activities in development cooperation analytics need to be modified to cope with:

1. Communities who are estranged, terrified and distrustful.
2. Communities vulnerable to economic exploitation and physical violence.
3. Opportunistic leaders, concomitantly playing the role of perpetrators and protectors.
4. Development cooperation providers that are exposed to risk.

These circumstances leave little room to engage stakeholders in conversations, interviews and discussions that ensure their effective involvement in the life cycle of development cooperation projects and programs. Therefore, data collection, analysis and presentation methods and operational procedures should be modified to reflect field conditions. However, adapting current qualitative and quantitative methods of development cooperation analytics to conditions 1–4 face limitations that can be overcome by participatory and simulation approaches.

The reminder of this document outlines a participatory framework based on participatory computational social science that is useful when standard approaches to development cooperation analytics fail. Section 2 where the focus lies and where we will describe and discuss the methodological framework and the different methods applied. In Section 5 we will show anonymized results and discuss their usefulness against the methods applied. We conclude in Section 6 with recommendations and for analytic work in areas affected by armed conflict.

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2 APPROACH

2.1 Methodology

We employ a participatory method to elicit unobserved powerbroker beliefs on the development situation and population needs. The survey consists of a semi-structured, multidimensional questionnaire that covers livelihood, security, governance, economy, and current development projects managed by the NGO. Survey questions are divided into general and specialized. The former is designed for every respondent; the latter for specific ones, such as powerbrokers, business people and farmers.

Often security conditions prevent taking a representative survey and development workers need to be aware of and sensitive to who to meet where, when and how often, and what questions they can ask. Even powerbrokers felt more comfortable talking to us discretely and did not appear to be in full control over their area of influence. To rectify coverage bias under such circumstance, we reached out to powerbrokers and landowners through a middleman, remaining open to anyone who was available to us. At the same time a local surveyor who possessed relatively free access to the area conducted short individual interviews. We interviewed individuals and groups at secure locations, convenient to us and interviewees.[1] All this was done as transparently as possible, including telling people who we are and why we conduct the survey, asking people for their informed consent, marking all questionnaires with the DAP logo, and equipping the surveyor with a DAP ID card. We sought to protect respondents' safety and to elicit information that helps to better tailor existing development projects and subsequent projects to their needs.

The participatory need elicitation method was designed as a development game where powerbrokers were given a map of their geographic environment, a selection of development projects and a budget level and were asked to allocate development projects on the map as long as the budget lasts. Figure 1 shows a scene of the development game with the game board on the left and the reporting sheet on the right. The game is designed differently, depending on what unobserved attributes is to be elicited. The participatory approach complements the survey in terms of eliciting unobserved or unknown needs and beliefs on mixes of development projects and transfer channels across the community that receives development cooperation.

We denoised and fuse results of games using a computational procedure. The procedure is formalized in the next section. Before that, we describe competing approaches and inspirations for our research as well as we present the raw results of the surveys.

2.2 Related approaches

Elicitation of population needs in Afghanistan The keystone to population need elicitation in Afghanistan is the Tactical Conflict Assessment and Planning Framework used by ISAF. TCAPF is composed of four simple questions (Office of Military Affairs, USAID 2011):

1. "'Has the number of people in the village changed in the last year?"'
2. "'What are the most important problems facing the village?"'
3. "'Who do you believe can solve your problems?"'
4. "'What should be done first to help the village?"'

All questions are followed with "'Why"'. Non-military organizations such as USAID, the UN, Civil Affairs and various NGOs also adopted variants of ISAF. Some organization, such as Asia Foundation (Tariq, Ayoubi, and Haqbeen 2011), still use large surveys with complex 50-question survey that uses closed-ended questions like "'Do you have enough electricity yes or no?"' or "'Do you have enough water

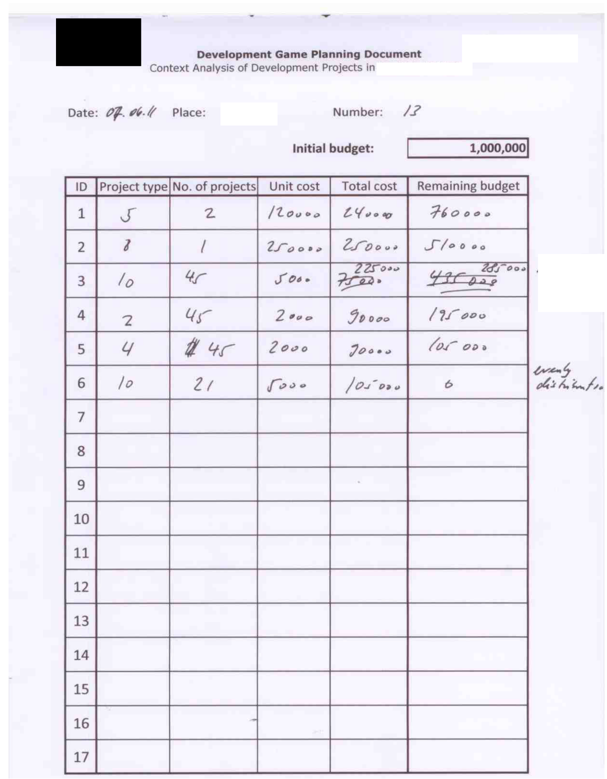
[1]The original idea was to exploit the survey for a snowball sampling of the population. Powerbrokers would have been invited for an interview at the end of which we would have asked them for permission to conduct interviews in their constituencies (Maletta and Favre 2003). While this could have introduced a bias to the survey as powerbrokers could have pointed us to a selection of subservient people, it would have enabled operating in an insecure area under their umbrella. Furthermore, we would have not jeopardized our survey through creating collusive behavior and thus putting respondents at risk.

LRG-BALOZ: Rules of the Game

1. The aim of the game is to allocate development projects in the Baluchi Valley given a budget. This is a game. The game can help us to better understand your needs and requirements. No future funding decisions are antedated by it.
2. We will first explain you the game.
3. In front of you lies a simplified map of the Baluchi Valley. The best way to orient yourself is with the help of the seven major villages in the Baluchi Valley, which are also indicated.
4. Development projects are symbolized by picture cards. Each project has its cost.
5. You are given a fixed, virtual budget.
6. If you agree, we will play the game twice. In the first round your budget is $1,000,000; in the second round it is $500,000. The two rounds are independent of each other.
7. Place the development project picture cards on the map where it makes sense for you to place them.
8. Deduct the price of the project costs from the budget.
9. Place as many development project picture cards on the map as you want, but only as long as your budget lasts.
10. Once you have decided not to place any development project picture cards on the map anymore or once your budget is used entirely the game is over and a picture of the map and the allocated development project picture cards is taken.
11. After the picture is taken, please explain to us why you have allocated the different development project picture cards the way you did.

Type	Icon	Project	Cost
1		Building a protection wall	280
2		Building a drinking water well	2
3		Planting tree saplings	2
4		Providing seeds and fertilizer	2
5		Building a canal or repairing a karez	120

Type	Icon	Project	Cost
6		Building a microdam	35
7		School with a year of teacher	300
8		Building a community clinics	250
9		Building a tributary road	300
10		Solar panels or MHP	5
11		Bazaar revival	100



[redacted]

Development Game Planning Document

Context Analysis of Development Projects in

Date: 07.06.11 Place: Number: 13

Initial budget: 1,000,000

ID	Project type	No. of projects	Unit cost	Total cost	Remaining budget
1	5	2	120000	240000	760000
2	8	1	250000	250000	510000
3	10	45	5000	~~75000~~ 225000	~~435000~~ 285000
4	2	45	2000	90000	195000
5	4	45	2000	90000	105000
6	10	21	5000	105000	0
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					

evenly distribution

Figure 1: A participatory experiment called a development game to elicit unobserved stakeholders' needs and incentive patterns. The lower left panel shows the game board with development projects allocated by a powerbroker with the budget of $\$1,000,000$. The lower right panel shows the document accompanying the game board and used to report the stakeholders allocation decisions. Locations, project details and stakeholder names are whited out.

yes or no?"', but ability to conduct and repeat such a survey requires a rather permissive environment and focused interviewee. Various attempts to validate TCAPF have been undertaken. In particular, an natural "'experiment"' has been conducted by the British forces using information collected in the city of Lashkar Gah, in Helmand Province, back in late 2007 and early 2008. It was found that TCAPF and projects allocated on its basis allowed to exert a greater influence on population attitudes then competing methods.

A significant fraction of rural development money in Afghanistan is disbursed not through ISAF or NGOs, but rather through the National Solidarity Programme (NSP) which was created in 2003 by the Ministry of Rural Rehabilitation and Development. Under the NSP, communities elect their leaders and representatives to form voluntary Community Development Councils (CDCs) through a "'transparent and democratic process"'[2]. These CDCs are given a certain budget and can prioritize needs and plan and manage spending of that money on their own behalf. No explicit audit is required afterward.

Compared to our solution, TCAPF or other survey methods does not include an aggregation approach nor explicit safeguards for deception detection and noise filtering. Neither includes a formal way to translate collected information into a future course of action and prioritize projects. CDCs are not assuredly transparent and dynamics of the local political economy may actually contribute to increasing local violence caused by competition over money rather then to stabilize the communities and their relationships with neighbors. As we will argue further, our less intrusive approach holds promise of being more robust with respect to highly differentiated and fractionated communities. Methodologically, it is derived from the concept of participatory simulation rather than survey. We discuss this concept next.

Participatory simulations and mapping In 2001, Olivier Barreteau proposed to jointly use multi-agent systems and role-playing games for purposes of research, training and negotiation support in the field of renewable resource management. Later, the method has been matured into an branch called "'agent-based participatory simulations"'. These simulations are multi-agent systems where human participants control some of the agents. As argued in (Guyot and Honiden 2006), because all interactions are computer mediated, they can be recorded and this record can be processed and used to improve the understanding of participants and organizers alike. Because of the merge, agent-based participatory simulations decrease the distance between the agent-based model and the behavior of participants. Agent-based participatory simulations allow for computer-based improvements such as the introduction of eliciting assistant agents with learning capabilities. Today, the approach has matured such that various off-the-shelf tools for participatory simulation exists. Those include as HubNet (Wilensky and Stroup 1999) or PET (AITIA 2010). Such tools allow one to either create a participatory simulation from scratch or extend an existing non-interactive simulation into a participatory one and use agent-based participatory simulations in a classroom or laboratory settings.

Concept of participatory simulation has been also translated to resource management in conflict areas and transitional societies. For example, the Strategic Economic Needs and Security Exercise (SENSE) has been developed by Dr. Richard H. White of the Institute for Defense Analyses together with the U.S. Institute of Peace (USIP 2011). SENSE is a participatory, computer simulation that focuses on negotiations and decision-making in a post conflict environment and it simulates the resource-allocation challenges confronting national and international decision-makers. The primary activity in SENSE is negotiation between and among those participating in the simulation. SENSE has been used in the Afghanistan, but to support very high level, political decision making and negotiation on the level of the central ministries.

A special case of participatory simulation experiments include negotiation over map. Participatory mapping is often applied in case of indigenous lands and resources, where land titles and use right have not been previously secured formally. It is also seen as a tool of empowering participants or give them greater authority in negotiations with the government. A few cases where the benefits, costs and unintended consequences of such an approach have been thoroughly explored include herders in Tibet (Bauer 2009) and Bolivian Amazon (Reyes-Garca, Orta-Martnez, Gueze, Luz, Paneque-Glvez, Maca, Pino, and Teame 2012).

[2]Description of the program can be accessed at http://www.nspafghanistan.org/. Detailed description of impact evaluation experiments for NSP is provided by (Beath, Christia, and Enikolopov 2012)

Limitation of the infrastructure available in Uruzgan forced us to use game board, rather than a simulation, as a medium of elicitation. For the similar reason, even though other powerbrokers are implicitly present in the game, there is no opportunity for the participant to interact with them in a repeated fashion. For this reason, our pen and paper simulation features only two-agent: the interviewee and the interviewer.

Research frontier in belief elicitation Development needs vary from one community to another. Some of the variance stems from the differences in modes of livelihoods and production, some of it is function of previous exposure to development. Some is purely cultural. In essence, we face a problem of eliciting a mix of private, but shared, information and fully subjective beliefs. Subjective judgments and beliefs, an essential information source for development practitioners, are most problematic because there are no public criteria for assessing judgmental truthfulness of the provided information. Various aspects of elicitation methods which can be applied in such a context have been tackled by decision sciences, experimental economics and cognitive psychologists.

Decision scientists are often faced with the problem of preference elicitation. This problem is encountered when building interactive decision support systems to choose products and make help humans make better decisions, especially in on-line contexts. Methods applied include traditional utility function elicitation via revealed preferences and analytic hierarchy process methods, example critiquing, needs-oriented interaction, comparison matrices, CP-network, preferences clustering & matching and collaborative filtering. A survey of those methods is provided by (Chen and Pu 2004). Some of the methods do not explicitly learn preferences, but rather elicit the desired end-state directly. For example, Hunch Engine approach developed by Icosystem (Biever 2006, Hurley, Peterson, and Shogren 2007), uses a genetic algorithm whose evolutionary direction can be nudged by the person running it by critiquing carefully selected sample solution.

Experimental economists solve the elicitation problem by designing the structure of interaction and incentives such that truthful revelation becomes the most rational behavior accessible to interviewees. One such methods is the Bayesian Truth Serum (Prelec 2004). The method assigns high scores not to the most common answers but to the answers that are more common than collectively predicted, with predictions drawn from the same population. This simple adjustment in the scoring criterion removes all bias in favor of consensus: Truthful answers maximize expected score even for respondents who believe that their answer represents a minority view. The score function used in the Bayesian Truth Serum explicitly represent the cognitive process of the interviewee, assuming certain type of bounded rationality on his part (Bayesian Learning).

3 SURVEY RESULTS

This section summarizes the results of *development games* we played with powerbrokers to elicit livelihood needs of the population from participants in two steps. In step one, participants allocate agriculture, energy, infrastructure, irrigation, public services and water projects with known costs to 14 BV villages, given available budgets of 500 and 1000K. In step two, participants justify their project portfolios. For example, Figure 2 shows a powerbroker's two project portfolios.

Figure 3 shows average powerbroker and landowner project allocations in the villages. As such we have recovered a unified image of the needs of the population. We also estimated how uncertain this image is, because there lies uncertainty in estimating needs using observed powerbrokers allocations, see Figure 4. Powerbrokers may decide not to place a project in a particular village because they do not consider the welfare of that village important; think that the village does not have any needs; or believe that the needs are too large to be satisfied without depriving other villages whose needs are more important to him.

4 COMPUTAIONAL MODEL

4.1 Notation

Geography, power networks and population needs We will be designing a project portfolio for a specific `region`. That `region` has V villages, controlled or contested by B power brokers. The population

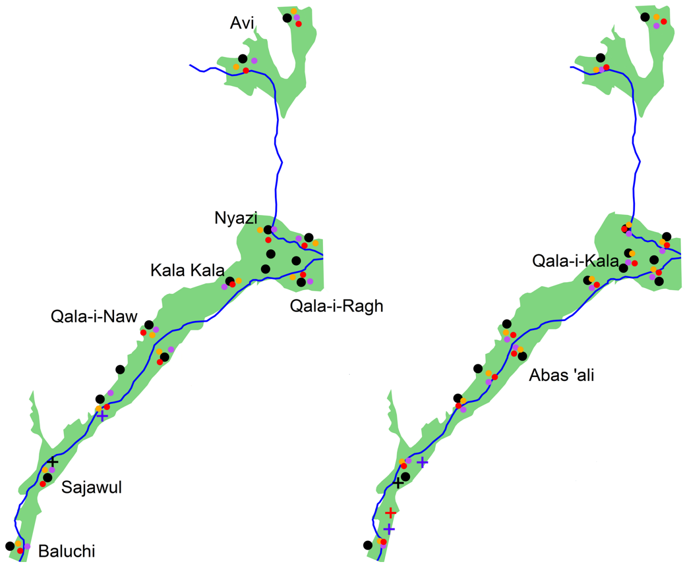


Figure 2: Spatial allocations of projects for a budget of 500K on the left panel and that of 1000K on the right panel recovered from a development game played with a powerbroker. A drinking water well is assumed to cost 2K, fertilizer and seeds 2K, a solar panel 5K, a revamped karez 12K, a microdam 35K, average-length tributary road 300K, a clinic 300K, and a school 300K. Legend: + karez, + tributary road, + school or clinic, ● drinking water well, ● fertilizer and seeds, and ● solar panel.

in each village has M need dimension. The `region` and description of the population needs is further described by the following variables:

- Square matrix `distances` is $V \times V$ matrix which describes travel distances between villages.
- Rectangular matrix `villageWeights` is $B \times V$ matrix. Elements in each row are in $[0, 1]$ and sum to 1. This matrix describes how much each power brokers is interested in welfare of population of a given village.
- Vector `maslowCoefficients` is an $M \times 1$ vector and codes weight or the ranking of each of the need dimensions for the population of the `region`.
- Three matrices `currentLevels`, `thresholdLevels` and `saturationLevels` are $\Re_+$, $V \times M$ matrices. They describe monetary or physical historical investment into each of the need dimensions in each of the villages, minimal amount of investment which starts making difference in life of people of that village and maximal investment beyond which population no longer perceives any improvement.

Within our framework, `region` description and interpretation of the variables is rather flexible. For example, elements of `maslowCoefficients` can be defined as weights that sum to 1 or as rankings of each of M need dimensions, depending on the structural form of the utility function of the general population. In our case we will use the additive linear utility function, with $M = 6$ and the following dimensions: AG (agriculture), IRR (irrigation), WS (water and sanitation), PS (public services: education and healthcare), EN (energy) and INF (transportation infrastructure). In principal, vector `maslowCoefficients` can differ by V and be subject to elicitation. In our case study, the mode of livelihoods are very homogenous and assumption of common hierarchy of needs seems reasonable.

In the case study, three matrices `currentLevels`, `thresholdLevels` and `saturationLevels` will hold monetary value of respective investments expressed in USD. We will demonstrate how to translate

Village	Historical spending	Dollar values													
		Total		500k						1000k					
		500k	1000k	AG	EN	INF	IRR	PS	WS	AG	EN	INF	IRR	PS	WS
Baluch	358	87	170	4	4	62	13	0	4	3	13	90	24	25	15
Sajawul	541	165	379	5	4	64	53	33	5	3	11	90	88	180	8
Khwaja Ahmad	261	76	131	5	4	31	27	0	9	5	18	28	12	55	13
Qala-i-Naw	43	27	94	5	4	0	13	0	5	1	13	0	12	60	7
Abas 'ali	161	44	29	5	5	0	0	28	5	2	11	0	12	0	4
Kala Kala (2)	167	9	52	4	2	0	0	0	3	3	16	28	0	0	5
Awi (2)	10	13	25	5	4	0	0	0	5	2	13	0	4	0	7
Qala-i-Kala	65	5	17	4	1	0	0	0	0	0	4	0	12	0	0
Nyazi	389	13	14	5	3	0	0	0	6	2	6	0	0	0	6
Abdullahkhan	0	8	39	1	3	0	0	0	4	1	9	0	0	25	4
Kala Kala (1)	55	11	11	5	3	0	0	0	4	2	6	0	0	0	3
Awi (1)	46	13	19	5	4	0	0	0	5	2	11	0	0	0	7
Qal'a-i-Ragh	347	12	10	4	4	0	0	0	4	2	4	0	0	0	5
Karbala'i	0	14	11	5	4	0	0	0	5	1	4	0	0	0	6
Total	2444	499	1001	62	46	158	107	61	64	29	140	236	163	345	89

Figure 3: Average allocations to project categories in villages by powerbrokers in (e). AG stands for agriculture, EN for energy, INF for infrastructure, IRR for irrigation, PS for public services and WS for water. Total 2009–10 denotes the amount spent on development projects in 2009–2010. Values are in USD $1,000$. Village names are anonymized.

those monetary value into actual project portfolios, given project costs and technologies described below. Matrix `currentLevels` is initialized by replaying projects available to us from historical record and is not a subject of elicitation. Similarly, `distances` matrix is calculated using map of roads and terrain of the `region`. Matrices `thresholdLevels` and `saturationLevels` will be the primary target of the elicitation. We assume that those matrices are perceived with equal precision by all the interviewees, regardless of their location or role. It is possible to extend our approach by an individual specific error term which has both general and spatial component.

An alternative specification for matrix `villageWeights` is a $B \times B$ matrix of how much each power broker hates other power brokers or cares about their welfare. In that case elements of `villageWeights` are in $[-1, 1]$ range. Such a formulation requires that the search algorithm is additionally provided about the location of power brokers for completeness. Finally, one can also fix the matrix such that weight of each village is common for all power brokers and proportional to population which inhabits that village. This corresponds to assuming that all power brokers are fully altruistic and indifferent to ethnic or tribal affiliation of the villagers. In our case study, we will use this last variant.

Development projects, their costs and technologies In addition to name and cost per unit, each project type is characterized by project `technology`:

- `needsFilled`: Need dimensions $\leq M$ it satisfies.
- `needImpacts`: Physical or monetary contribution of the project to need satisfaction at each of the need dimensions.
- `radius`: A positive number showing geographic reach of the project, assumed to be the same across all `needsFilled`.
- `maxReps`: Maximal number of collocated projects of the same type within the `radius`.

Consider the following project technology as an example (all values are in 000's USD):

$$\begin{aligned}\texttt{technology}(6) \;=\; & \text{Microdam}, \texttt{cost} = 35, \texttt{needsFilled} = [2, 3, 6], \\ & \texttt{needImpacts} = [20, 15, 10], \texttt{radius} = 500, \texttt{maxReps} = 1.\end{aligned}$$

Microdams is project type 6, contributing to irrigation, water and sanitation, and energy as need dimensions $2, 3$, and 6. The monetary amounts contributed to each of the dimensions are 20, 15 and 10. At the project cost of 35, sum of each of the dimensions is larger than the cost of the project as such. This happens because various engineering elements of the project, such as dam used to store both water for irrigation and the micro hydro power generator are reused. Only one microdam is allowed in each 500 meter radius. Parametrization of the remaining project types is given in Table 1.

id	name	`cost`	`needImpacts`	`radius`	`needsFilled`	`maxReps`
1	Protection wall	270	[0 270]	2000	[2 6]	1
2	Drinking water well	2	2	500	3	21
3	Tree saplings	2	2	500	1	21
4	Seeds and fertilizer	2	2	500	1	21
5	Canal or a karez	120	[120 10]	1000	[2 6]	1
6	Microdam	35	[20 15 10]	500	[2 3 6]	21
7	School	300	300	15000	4	1
8	Community clinic	300	300	15000	4	1
9	Tributary road	300	300	4000	6	1
10	Solar panels	5	5	500	5	21

Table 1: Project technologies available to our interviewees. Dimensions of the `maslowCoefficients` vector correspond to the following need dimensions: AG, IRR, WS, PS, EN and INF.

Finally, within our framework a project portfolio is a spatial list of instances of projects:

$$\langle\langle \texttt{technology}, \texttt{location}, \texttt{repetitions} \rangle\rangle$$

For example, one could consider the following set as an example of a valid project portfolio:

$$\langle \text{Protection wall}, \text{Village } 1, 1\rangle$$
$$\langle \text{Tree saplings}, \text{Village } 2, 10\rangle$$
$$\langle \text{Tree saplings}, \text{Village } 3, 10\rangle$$
$$\langle \text{Tributary road}, \text{Village } 3, 1\rangle$$

For each project portfolio and a powerbroker, we will determine a scalar measure of the fitness of the project portfolio:

$$\text{score} = \text{projectPortfolioImpact}\,(\text{projects}, broker)$$

As described previously, depending on `villageWeights`, the project portfolio impact function can implement preferences of benevolent social planner (an example laid out on Algorithm 1) or a self-interested rent seeker. The nature of behavioral search heuristic that is used to emulate power brokers playing our game and in boundedly rational fashion trying to maximize score and set of associated optimization procedures allowing us to seek matrices `thresholdLevels` and `saturationLevels` is described in the next section.

4.2 Inverse simulation and portfolio optimization problems

In order to find the private beliefs of interviewees about the minimal and maximal investment needs over the area of interests, we will specify how their project allocation behavior during the experiment depends on their private beliefs. Later we will define an optimization problem which will search for the set of private beliefs which makes the simulated behavior match the one we observed in the real life. Since we will have a global optimization procedure trying to find inputs of the behavioral search heuristic that make its results match a set of predetermined targets, we call this process an inverse simulation problem.

Formally, we will find `region` estimates by solving the following optimization problem:

$$\texttt{region} = \underset{mask(\texttt{region})}{\text{argmin}} \; distance(\text{greedy search } (\texttt{region}), \text{empirical behaviors})$$

where:

- argmin is a genetic algorithm searching for global minima of the distance function.
- $mask$ is function which fixes all but `thresholdLevels` and `saturationLevels` fields of region.
- distance is an absolute matrix divergence between `currentLevels` matrices calculated from experimental and simulated power brokers after proposed project portfolios are implemented.
- Algorithm 4 describes the greedy search heuristic.

By repeating argmin process and using kernel density estimators we can obtain confidence intervals and joint confidence intervals over need thresholds. Afterward, we define a separate global optimization problem to find the the robust project portfolios which respond to those measures of need scenarios. In the next section

```
Input: projects, technology, region
Output: score ∈ ℜ+
Initialize newLevels = region.currentLevels
foreach project p ∈ projects do
    affectedArea=find(distances(p.location,:)¡=p.type.radius)
    foreach Location l ∈ affectedArea do
        foreach Need n ∈ type.needs do
            newLevels(l,n) += p.repetitions*p.type.impacts(n)
        end
    end
end
Return score=socialSlack(newLevels)
```

Algorithm 1: Procedure projectPortfolioImpact. Note that this procedure depends on Algorithms 2 and 3.

```
Input: newLevels, region
Output: score ∈ ℜ+
Initialize score=0
foreach Location l ∈ region do
    score = score + villageWeights(l)*communitySlack(newLevels(l),l);
end
Return score
```

Algorithm 2: Procedure socialSlack.

```
Input: newLevels, region, location l
Output: score ∈ ℜ+
Initialize score = 0
foreach Need n ∈ needs do
    if newLevels(n) ≥ saturationLevels(l, n) then
        score+ = maslowCoefficients(n) * 1
    else
        if newLevels(n) ≥ thresholdLevels(l, n) then
            score+ = maslowCoefficients(n) * (newLevels(n)−thresholdLevels(l,n)) / (saturationLevels(l,n)−thresholdLevels(l,n))
        end
    end
end
Return score
```

Algorithm 3: Procedure communitySlack.

```
Input: region, broker b, budget
Output: project portfolio
projects=[]
while budget ¿ 0 do
    tempBestProject=[], tempBestCost=0, tempBestScore=−∞
    foreach project type t do
        foreach location l do
            foreach repetition r=1:t.maxReps do
                projectCost=r*t.cost
                if projectCost ¡ budget then
                    score=projectPortfolioImpact(projects ∪ ⟨t, l, r⟩, b)
                    if score ¿ tempBestScore then
                        tempBestScore=score, tempBestProject=p
                    end
                end
            end
        end
    end
    portfolio = portfolio ∪ tempBestProject
    budget = budget-tempBestCost
end
Return portfolio
```

Algorithm 4: Procedure greedy search.

5 MODELLING RESULTS

Average allocation tables as the one depicted in Figure 3 help design project portfolios that potentially reduce population grievances. For example, under the DNH policy we can design project portfolios that ensure a minimum level of need satisfaction for *all* of the population. Furthermore in line with DNH we can design portfolios that satisfy population needs such that the difference between best and worst-off segments of the population and tensions between different groups are minimized. We may do this by fixing a need satisfaction threshold for the population of each village and find the cheapest project portfolio that reaches the threshold. Table 2 contains results of such an analysis for four thresholds.

Villages	Necessary investments				Historical investments			Violence levels			
	Need satisfaction				Year			Event		Fatality	
	25%	50%	75%	100%	< 2009	2009	2010	2009	2010	2009	2010
1	0	19	270	323	0	0	358	33	25	11	14
2	0	83	83	100	4	438	99	17	8	19	16
3	213	270	277	280	0	241	20	16	13	19	7
4	0	0	127	303	0	13	148	6	3	8	5
5	609	742	755	757	0	0	43	8	51	48	25
6	30	30	53	53	0	167	0	36	19	49	29
7	243	280	299	301	0	0	65	19	4	1	0
8	0	0	8	144	0	41	348	25	48	24	3
9	0	66	99	120	0	0	0	5	5	3	1
10	0	124	124	125	0	53	2	2	2	0	0
11	0	16	48	48	0	0	10	1	7	0	0
12	0	24	43	43	19	0	27	2	1	1	0
13	0	0	0	45	0	24	324	22	29	2	0
14	0	9	17	18	0	0	0	13	0	2	0
Sum	1095	1663	2202	2659	23	977	1444	205	215	187	100

Table 2: Additional investment necessary to bring the least developed village to a given level of need satisfaction. The last two blocks present historical trends in investment and violence levels in villages. We estimated the inherent uncertainty in aggregated needs and derived a measure that indicates additional development investment necessary to bring the least developed village to any need satisfaction level. Values are in \$ $1,000$. Village names are anonymized in the same order as in Figure 3.

The fact that some villages do not receive direct funding means that they may either be already above the threshold or benefit from the spillover of development projects such as schools, clinic, protection walls or tributary roads. For example, most villages have already passed the 25% needs threshold. With an additional $1,100,000$ invested in mid and upper valley we can ensure that the least developed village has at least 25% of its needs met while bringing the average level of need satisfaction to around 60%. Additional steps are cheaper as the most expensive infrastructure in most populous places is already built. At some point the issue of underutilization and long-run sustainability of projects creeps in and it may not be economical to have all the needs of every community satisfied.

We have not only recovered a unified image of the needs of the BV population, but also estimated how uncertain this image is. Figure 5 shows the average fraction of the total needs of the BV that a given level of investment satisfies under an optimal project portfolio. Average fractions of satisfied needs vary because of uncertainty in estimating needs using observed powerbrokers' allocations. Suppose a powerbroker decides not to place any project in a particular village. It may be because (a) he does not consider the welfare of that village important; (b) thinks that the village does not have any needs, or (c) believes that the needs are so large that given his budget he cannot reasonably reach saturation points without depriving other villages whose needs are more important to him. Controlling for these possibilities requires engaging powerbrokers from different communities and having them play a number of development games with different designs. Due to security constraints, we could not arrange for a sufficient number of such sessions.

6 Summary

An experimental, participatory technique in the form of a development game was applied to elicit yet unrecovered needs and incentive patterns. We estimated the inherent uncertainty for the aggregated needs

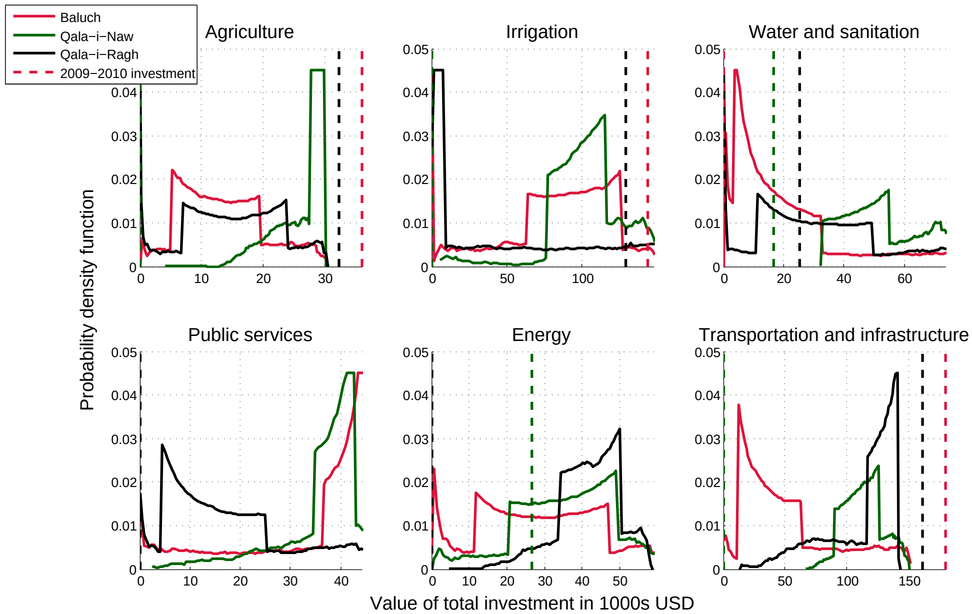


Figure 4: Measurements of uncertainty of need saturation threshold for three selected villages.

and derived a measure that tells us something about the additional investment in the form of development cooperation that is necessary in an area to bring the least developed village in that area to a satisfying level.

We believe that our computational framework is a first step toward developing innovative context analysis, monitoring and evaluation instruments. Would we not have had an approach that somehow incorporates at least some of these requirements, we think we would not have been able to produce this context analysis.

REFERENCES

AITIA 2010. “The Participatory Extension (PET)”. Technical report, AITIA International Inc.

Bauer, K. 2009. “On the Politics and the Possibilities of Participatory Mapping and GIS: Using Spatial Technologies to Study Common Property and Land Use Change Among Pastoralists in Central Tibet”. *Cultural Geographies*.

Beath, A., F. Christia, and R. Enikolopov. 2012. “Randomized Impact Evaluation of Afghanistans National Solidarity Programme (NSP)”. Technical report.

Biever, C. 2006, March. “’Hunch Engine’ Sharpens Up Your Half-baked Ideas”. *NewScientist* (2542).

Chen, L., and P. Pu. 2004. “Survey of Preference Elicitation Methods”. Technical report, Ecole Politechnique Federale de Lausanne (EPFL).

Guyot, P., and S. Honiden. 2006. “Agent-Based Participatory Simulations: Merging Multi-Agent Systems and Role-Playing Games”. *Journal of Artificial Societies and Social Simulation* 9.

Hurley, T. M., N. Peterson, and J. F. Shogren. 2007. “Belief Elicitation: An Experimental Comparison of Scoring Rule and Prediction Methods”. *Journal of Risk and Uncertainty*.

Maletta, H., and R. Favre. 2003, August. “Agriculture and Food Production in Post-war Afghanistan: A Report on the Winter Agricultural Survey 2002–2003”. Technical report, United Nations Food and Agriculture Organization, Kabul.

Office of Military Affairs, USAID 2011. “Tactical Conflict Assessment and Planning Framework”.

Prelec, D. 2004. “A Bayesian Truth Serum for Subjective Data”. *Science* 306:462–466.

Reyes-Garca, V., M. Orta-Martnez, M. Gueze, A. C. Luz, J. Paneque-Glvez, M. J. Maca, J. Pino, and T. B. S. Teame. 2012. “Does Participatory Mapping Increase Conflicts? A Randomized Evaluation in the Bolivian Amazon”. *Applied Geography* 34.

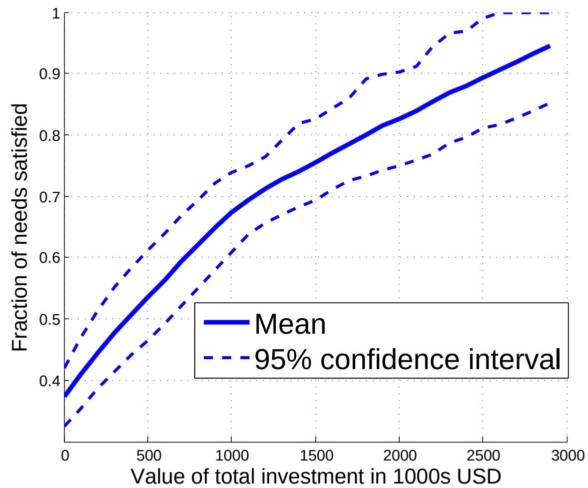


Figure 5: Additional investment to reach any level of average need saturation for the Baluchi Valley population. We estimated that the current level of needs saturation in the valley is around 35%.

Tariq, M. O., N. Ayoubi, and F. R. Haqbeen. 2011. "Afghanistan in 2011: A Survey of the Afghan People". Technical report, The Asia Foundation.

USIP 2011. "The Strategic Economic Needs and Security Exercise". Technical report, United States Institute of Peace.

Wilensky, U., and W. Stroup. 1999. "HubNet". Technical report, Center for Connected Learning and Computer-Based Modeling, Northwestern University.