

# DISASTER RESILIENCE AND SOCIAL CAPITAL. ANALYSIS OF SOCIAL NETWORKS IN OUTLYING NEIGHBOURHOODS OF THE CITY OF CUSCO, PERU

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## I. INTRODUCTION

The latest United Nations International Strategy for Disaster Reduction report (UNISDR, 2015) indicates that natural disasters cause extraordinary annual economic losses of around 300 billion dollars. The trend is also for higher mortality and economic losses associated to extensive risks, defined as being minor and recurrent (UNISDR, 2009), in low and middle income countries.

Given this overall picture of increased risk from disasters, much conceptual knowledge has been developed to help understand its root causes and improve respective management (Olcina Cantos, 2008). Disaster risk studies began in the natural sciences, with initial interest focusing on natural phenomena, which bore all the explanatory weight. That approach was criticised for not considering different risk aspects and was labelled a “physicalist view” (Hewitt, 1983).

As it became clear that similar dangers produced different disasters, it was inferred that risk derived from a natural phenomenon’s interaction with society, which could be more or less liable to suffer damage; the term vulnerability was then coined, originating in the social sciences (Blaikie et al, 1994; Wisner et al, 2003; Cutter et al, 2003; Birkmann, 2006).

Resilience is one of the latest concepts developed in this context. The various respective approaches (Manyena, 2006) can be grouped in two categories:

- Those that emphasise ability to return to the same state after a disaster (Campanella, 2006; Hamilton, 2009);
- Those that also assess broader processes whereby a social system recovers and learns from disasters that have happened and adapts to meet future ones (Adger 2005; Folke, 2006; Cutter et al, 2008; Zhou et al, 2010; Cutter and Corendea, 2013).

Social capital is one of the factors that contribute to disaster resilience (Pelling, 1998; Pelling, 2003; Nakagawa and Shaw, 2004; Adger et al, 2005; LaLone, 2012; Méndez, 2012), especially in peripheral or marginal environments. Various authors have included it among key indicators for evaluating resilience (Baral & Stern, 2011; Prashar et al, 2012; Ainuddin & Kumar Routray, 2012).

For example, a recent study (Aldrich, 2012) shows that the population's recovery rate after the 1923 Tokyo earthquake is best explained by considering factors such as social capital rather than using other aspects such as damage level, population density, education level or population's economic resources.

Two concepts of social capital can generally be distinguished, one cultural and the other structural. Per the cultural concept (Putnam, 2000), social capital refers to trust, norms and networks that facilitate social cooperation and coordination for mutual benefit. In turn, per the structural concept (Burt, 2000; García-Valdecasas, 2011), social capital is associated to resources that an individual or group can access due to the respective relationships with members of the social network, resources understood to be material or information. Although the latter is currently the minority approach, very interesting examples of its application can be found (Varda et al, 2009; Tobin et al, 2014), and it is the chosen option in this study.

Some authors (Putnam, 2000; Woolcock, 2002; Nakagawa & Shaw, 2004), hold that three forms of social capital or relationship types can be distinguished in a group: bonding relationships occur within a group, e.g. resulting from interaction in socialisation or participation spaces; bridging relationships occur horizontally between different groups, e.g. between neighbourhoods that carry out joint activities; finally, linking relationships occur vertically, e.g. between a neighbourhood association and local government. Hence bonding relationships allow us to study social cohesion, bridging relationships social ties and linking relationships social integration (Lozares et al, 2011).

Bearing in mind these different relationship forms, it can be stated that the most resilient neighbourhoods are those presenting solid relationships of the three types (Tobin et al, 2014). Nakagawa and Shaw (2004) have shown the importance of social capital in post-disaster recovery, using the same categories of bonding, bridging and linking used in this article. Yet their assessment was based on a set of indicators and not on network analysis.

Note, in any event, that the relationship types do not all contribute to resilience in the same way. When only bonding connections are present it is hard to assimilate the innovations needed to adjust to changes. This is due to social restrictions and low diversity resulting from lack of coordination with other stakeholders, therefore leading to low resilience (L. Newman and Dale, 2005). A balance between bonding, bridging and linking connections is thus often necessary.

## **II. FIELD OF STUDY: OUTLYING NEIGHBOURHOODS OF CUSCO**

The study scope encompasses 18 peripheral neighbourhoods of the city of Cusco, Peru, which are the focus of a broader development cooperation project for managing disaster risk. During the project's conception the area was identified as a critical sector, whereby it was subject to intervention. It is characterised by steep slopes and the presence of ravines, where the most recurrent dangers include landslides and floods; it is also a seismic zone.

The occupation process is markedly informal, i.e. it has taken place in the absence of urban planning. The structure was generated by the main road, which conditions growth therefrom. The oldest neighbourhoods are those closest to it, while more recent ones occupy less accessible areas. The population is characterised by low levels of income and education.

None of these neighbourhoods were originally endowed with water, drainage and road services, nor were they legally recognised by the local government. This led the residents to organise in neighbourhood associations, the aim being to demand recognition and the supply of those services. At present, only 6 neighbourhoods are formally recognised; they were the first to be settled and are therefore closer to the main road, making it easier for the state to intervene in them.

Those associations comprise the neighbourhoods' main participation and socialisation space. They have a governing council democratically elected every two years and members representing each family that lives in the neighbourhood. Activities include ordinary monthly assemblies and extraordinary ones held when necessary. They also carry out communal tasks, also called chores, such as cleaning streets and drains before it rains, as well as forestation activities and others when required due to intervention by an institution.

## **III. METHODOLOGY**

The information used in this study was obtained from visits to neighbourhood assemblies and interviews with leaders of neighbourhood associations. A total of 18 pre-arranged structured interviews were conducted, one with each leader. Each assembly was visited at least once, in some neighbourhoods up to three times. Among other information obtained from the interviews was the number of assemblies and communal tasks carried out during the last year, the number of participants, the number of communal tasks undertaken jointly with other neighbourhoods during the last year and the degree of relationship with the defence front, a second-level organisation grouping a total of 80 area neighbourhoods, and with the local government. The software used was QGIS for mapping and Gephi (Bastian et al, 2009) for network analysis.

To obtain the social capital a network analysis of the neighbourhoods' bonding, bridging and linking relationships was conducted. Note that all networks or graphs, as in mathematics, comprise two kinds of elements: a set of nodes, also called vertices or points, and a set of connections, which are also called edges or lines.

To determine the bonding relationships a bipartite or bimodal graph was produced for each neighbourhood. It was later projected onto a unimodal graph, in which their average degree was calculated. The two sets of initial nodes are formed on one side by the families

and on the other by participation spaces in the last year, i.e. assemblies and communal tasks. The connections join the families that participated in a given space. The projection generates a network comprising only families, wherein those that participated in common spaces are related to each other; the connections' weighting will be greater the more the shared common spaces.

The process mentioned above, construction of bimodal graph, projection onto unimodal graph and calculation of average degree, is simplified in this paper by an equation (equation 1) to directly obtain the neighbourhood's level of bonding relationships:

$$\text{bonding} = \frac{a n_a (n_a - 1) + f n_f (n_f - 1)}{n} \quad (1)$$

where  $a$  is the number of assemblies held annually,  $n_a$  the number of families taking part in the assemblies,  $f$  the number of chores [*faenas*] or communal tasks carried out annually,  $n_f$  the number of families participating in the chores and  $n$  the number of neighbourhood families.

The neighbourhoods' bridging level was obtained based on relationships between different neighbourhoods. A directed network was constructed for that purpose, weighting connections based on identification and acquaintance with leaders from other neighbourhoods, and the number of joint communal tasks over the last year. The value assigned to each neighbourhood was obtained using the PageRank metric, based on an algorithm that scores a node's centrality based on the centrality of its neighbours divided by their outdegrees; neighbouring nodes are those that have a direct relationship in the network (Newman, 2010). In this case, a neighbourhood's centrality (node) would be measured by considering relations with its neighbours in the network, though also taking into account the importance of those neighbourhoods based on their mutual relationships.

To determine linking relationships a network was produced between neighbourhoods and higher-level organisations – the municipal government and the second-level defence front (Fundizonoc) grouping 80 area neighbourhoods. The metric used in this case was node degree.

Finally, to obtain the social capital of each neighbourhood the values obtained for each of the studied relationships were first standardised by subtracting the arithmetic mean and dividing the result by the standard deviation. Second, those standardised values were added up. Neighbourhoods with higher social capital are understood to be those with a high level in each of the three relationships considered, thereby making them more resilient.

## IV. RESULTS

### IV.1. Bonding

To determine bonding relationships for each of the neighbourhoods the process indicated above in the methodology was carried out. The process for the Pedregal neighbourhood is shown as an example. In the initial bipartite graph of this neighbourhood, the black nodes are the participation spaces and the grey nodes the families. The connections join families to spaces they participated in during the last year. There are 70 families in all, of which 60

participated in 12 assemblies in the last year and 55 took part in 6 communal tasks. The nodes without connections correspond to families that did not take part in any activity.

The graph is projected to obtain another comprising solely the families. It shows more cohesive families that took part in assemblies and communal tasks, less cohesive families that only took part in assemblies, and families with no connections because they did not participate in any space. The average degree of the network for this neighbourhood is 861.43, obtained by equation 1. The results obtained for the bonding relationships show that the neighbourhoods with the highest bonding relationships are Camino Inca, Monte Horeb and Camino Real, while the lowest are Arco Tica Tica, Pucyupata, San Silvestre and Señor de Huanca. Finally, spatialisation of results enables the existence of a central axis with higher values to be discerned (Camino Inca, Monte Horeb and Camino Real), bordered by 11 neighbourhoods that would present lower social cohesion levels. Finally, a group of 4 outlying neighbourhoods is detected, presenting intermediate values.

## **IV.2. Bridging**

In the bridging network the nodes are neighbourhoods, where size shows centrality level obtained via PageRank. The connections are neighbourhood relationships; their width indicates the respective relationship's strength. Noteworthy characteristics of the network are diameter, which shows the number of steps between nodes farther away, in this case 2; average path length, i.e. mean number of steps by shortest path between all the network's nodes, here 1.4; and a mean degree with weights of 28.8, expressing the sum of the weighted connections of each of the nodes divided by the total number of the network's nodes. The highest scoring neighbourhoods are Camino Real, Arco Tica Tica, Camino Inca, Pedregal and Pucyupata; the lowest Portales de Tica Tica, Alto Curaca, Señor del Cabildo and Villa Rosario. Results are mapped, as in the previous case. Neighbourhoods with more mutual relations are those closer in the road network.

## **IV.3. Linking**

In the network of linking relationships the nodes on the top part are a second-level organisation and the municipal government, while the ones below are neighbourhoods. The connections represent each neighbourhood's level of integration with those organisations. A fair to weak level of vertical relationships is observed. There is more coordination with the defence front (Fundizonoc) that with local government. The most integrated neighbourhoods are Camino Real, Cuna del Inca, Pedregal, Señor de Coylloriti and Villa Rosario, while the least are Alto Curaca and San Silvestre.

## **IV.4. Social capital**

The social capital was obtained by standardising the values of the three aforementioned relationship types. Those values were then added up for each neighbourhood, an approximation that thus considers the three relationship types to be equally important for determining social capital.

## V. DISCUSSION AND CONCLUSIONS

The proposed analysis of social networks offers an approximation of social capital based on bonding, bridging and linking relationships. The resulting level of social capital is a vital component for disaster resilience in such neighbourhoods. Despite limits regarding data and analysis period, the proposed methodology is novel for its application to the study of spatial entities at various scales, especially in subject matter associated to the social component of vulnerability and disaster resilience.

In this specific case, some considerations must be made. As this an area with neighbourhoods that have similar socioeconomic needs and features, the level of bonding relationships is closely linked to the number of participants in assemblies and communal tasks. This fact is related to the social networks' very nature, as set out in the proposed equation for its calculation (equation 1). Hence, when participation in a neighbourhood shows a linear increase, bonding relationships increase at a faster pace, leading to what might be called social capital explosion. Mapping of this internal cohesion indicator shows a central axis of neighbourhoods with higher values, owing to the higher number of families in each neighbourhood and the respective higher degree of spatial consolidation. But the next-ranking neighbourhoods are outlying, most likely explaining their greater need to establish internal ties, while at intermediate and low bonding relationship level are a fringe of cases around the central neighbourhoods, which somehow replace their social cohesion by closer relationships with higher-level neighbourhoods.

Road network access notably contributes to the level of bridging relationships, with centralised spatial distribution of scoring. Hence the lowest-scoring neighbourhoods are also the least accessible. The ranking obtained by analysing modularity of inter-neighbourhood relations also coincides with a clear connectivity-vicinity relationship between neighbourhoods. That is, neighbourhoods that are closer and more connected to each other have a higher relationship level. This indicates the respective importance of a road network as a conditioner of social relationships involving neighbourhoods.

As for linking-type social capital, a medium level of relationships with the defence front and a low one with local government are observed. There is currently a citizens' governance crisis in the sector. Second-level organisations other than the defence front have emerged; some neighbourhoods maintain relations with the latter while others favour alternative organisations. This situation has weakened the defence front, though it continues to act as official intermediary with the local government. Also, coordination between neighbourhood organisations and local government can only take place when the neighbourhood is formally constituted, as the state cannot intervene in informal areas outside the legal framework. A neighbourhood's legal status therefore correlates to the level of linking relationships with the local government.

Although each of the bonding, bridging and linking relationships respond to specific dynamics, in the end the neighbourhoods with higher social capital are those that have a balanced distribution of positive scores in each of them. They should therefore be considered the most resilient. These neighbourhoods present higher social cohesion, closer ties to other neighbourhoods and more integration with second-level organisations and local government.

They thus have more access to existing resources in the social network, whether material or information, eventually resulting in advantageous conditions to tackle different disaster risk management phases from the neighbourhoods themselves.

Likewise, from the standpoint of policy to manage risk from higher ambits, such studies can supply knowledge of great interest. For example, if there is desire to introduce innovation in an area, it will be done in neighbourhoods that occupy central positions in the bridging network, because they have more influence on the other neighbourhoods; resources are thereby optimised. Conversely, if the aim is to improve the situation of less resilient neighbourhoods, steps should be taken to strengthen their internal cohesion, encourage participation, improve ties to other neighbourhoods and adopt policies that bring local government into closer contact with the neighbourhoods. Also, in the event of a disaster in any neighbourhood, it will be more efficient to seek help in neighbourhoods with which it has a closer relationship.

