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To dig or not to dig?
Place and perception in subsurface housing

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Abstract

Cities of the future are envisioned to be fully optimized, due to technological advancements, distributed sensor networks and automation. With the proliferation of new data sources, opportunities also exist for better understanding how people act and make decisions, as well as discerning the conditions in which they wish to live and what they expect from their surrounding environment. Following the recently proposed *normative strand* in urban planning, this study uses *distributed personal underground development* as a case study for extracting the values behind this controversial self-build movement, alongside observers' opinions obtained from associated web-based data.

Keywords: information technology, town and city planning, tunnels and tunneling

1. Introduction

1.1 Underground development in light of normative rationality

Modern cities are facing numerous challenges. There is a growing need to accommodate their increasing populations, ensuring comfortable, prosperous and sustainable co-existence of inhabitants, whilst at the same time minimizing the effects of both anthropogenic and natural stresses to safeguard population security. Simultaneously, city planning methods are undergoing gradual transformations under the influence of the proliferation of newly available data sources and tools, which enable its processing, visualization and interpretation. Increasing data volumes and diversity, commonly referred to as 'big data', open new avenues of urban understanding, promising to make cities more livable, with precisely executed functions, resulting in 'smarter' urban habitats. New data and new ways of working with this data therefore suggest more creative planning methods, capable of equally incorporating readings from distributed sensor networks and interpreting various social participatory undertakings within urban fabrics (Townsend, 2013). However, the search for custom-made ways of working, which incorporate underlying values of urban populations, is still regarded as a weak component within a predominantly process-oriented rational tradition (Flyvbjerg, 1998). This poses several risks, notably of ignoring constructive bottom-up trends and of overlooking negative experiences within so-called technically optimal systems; other criticisms are well documented. One example which highlights these

shortcomings is in *distributed underground development*, often regarded as a hobbyist niche (Garrett, 2012; Lackman, 2012) and not considered as a constitutive element in wider city planning (Bridge et al., 2005).

Underground development in urban planning is often referred to as an alternative solution where (i) there are significant space constraints/demand over ground, (ii) where development is limited due to land conservation purposes or (iii) where cost savings can be made, for example with regard to storage (ITA, 1990; Marker, 2009; Rogers, 2009). Most often, underground space is used to fulfill major city functions, including transportation and waste management, as well as containing major public utilities such as mains water, natural gas, electricity distribution and communications infrastructure (Yang et al., 2015); it is rarely considered as a potential space for living. This may be due to the fact that modern understanding of underground space lies predominantly in the context of ever-growing urban infrastructure, for example, the requirement for additional parking, road tunnels and rapid transportation systems. Nevertheless, there is wide variety of civic uses of the subsurface (Goel et al., 2012; Rogers, 2009), which also include its use for residential purposes; this function most commonly comprises utilizing underground space to support living (e.g., servant's quarters) or leisure activities (e.g. subterranean gyms and swimming pools).

Therefore, a degree of living underground is not a novel concept. Indeed, subterranean living has grown increasingly popular over the last thirty years as an important sector in the green building movement. According to various 'grey'

literature (Gray, 2015; Yoneda, 2014), thousands of people in Europe and America live in underground homes and countries including Japan, China and Singapore, where development space is at a premium, are particularly keen to build underground living spaces.

At this time, there are two main obstacles that deter more widespread development of underground living spaces: poor adaptation of the legal framework (ITA, 2000) and public perception (Gray, 2015).

In most countries, the legal framework is seen as the major obstacle (De Mulder et al., 2012; ITA, 2000). Increasing demands for underground solutions emphasize the need for better coordination of the utilization of underground space. However, a large number of different authorities and overlapping legislative documents must be consulted before a building permit can be obtained (Rönkä et al, 1998). At the same time, the lack of clear rules, methods and standards for underground construction also delay legal procedures, which are far more coherent for above-surface solutions (RAIB, 2014). For landowners, the right to use underground space is also often restricted in some way, either through land-use plans or legal praxis – moreover, they do not necessarily have the right to oppose activities of others under the surface (ITA, 1990, 2000).

The primary reason for the limited uptake of underground development is public perception (Garrett, 2012). There is a common prejudice against such spaces, often described as lifeless, dark dungeons, providing little access to what we all enjoy: light and connection to the surrounding environment. The importance of including

people's values in underground development was introduced by Dobinson and Bowens (1997), who stated that such controversial projects were likely to generate opposing opinions and that underground development is therefore "not an end in itself": Rather, it must be viewed as a means of achieving strategic objectives of the entire community (Dobinson & Bowens, 1997).

Nevertheless, personal underground development projects are taking place in several countries around the world (Gray, 2015). Predominantly captured by various media sources, they are commonly positioned in the discourse of eco-lifestyle and organic post-modern architectural trends, due to the unconventional lifestyle of the owners or the extraordinary design of the dwelling (e.g., Gary Neville's eco-house in Bolton, UK) (Pham, 2010). From a planning perspective, in light of the normative rationality, individual underground development, which manifests itself primarily via self-build projects (e.g., Chiswick and Holland Park residences in London, UK) (McCloud, 2012) or crowd funding of underground public spaces (e.g., New York's Lowline Park, US) (Leaver, 2014), can be considered as a valid demonstration of need to include local values into planning (Buunk & van der Weide, 2015). This movement, nevertheless, has received very little attention in academic literature. Its controversial nature also means that this topic is a good candidate with which to demonstrate the underlying values of urban living, their prioritization and modes of implementation.

The need for a better understanding of the underlying values involved in decision making is not unique to the 'urbanist niche movements': thus, Flyvbjerg (1998) has

specified this necessity for planning in general if it is to fulfill its social function of reflexivity and arrangement (Flyvbjerg, 1998; Buunk et al, 2015). Values can take different forms; they can be expressed by means of motive, incentive, desire or ideal for spatial development (Bardi & Schwartz, 2003). Also, they can be approached from several perspectives: first, by uncovering the reasons why the project took place in the first instance (that is, 'simple observation') and second, by revealing the reactions of others to such a development (that is, 'observing the observer') (Lovink, 2011).

Similar to the political and social sciences' concepts of power and meanings, values can only materialize by means of social interaction (Ardvisson, 2011; Bardi & Schwartz, 2003). Linguistic methods, therefore, have been widely adopted in planning research, where discourse analysis helped to provide insight into the frames and storylines by which actors create their views of spatial development issues (Silva, 2012). Specific phrases or sentences that are likely to characterize the personal motive or ideal behind a storyline are often used to identify values in these contexts. The most recent proliferation of new data sources has also opened opportunities towards understanding the values of the audience, which can be found encrypted, for example, behind the politics of information arrangement (e.g., Google's PageRank) (Brin & Page, 1997; Curme et al., 2014), amount of 'likes' and 'shares' (Bodle, 2011; Gerlitz & Helmond, 2013) or sentiments of the commenting lexicon (Feldman, 2013) around a particular city planning or development project. There is, therefore, scope to test these new media data sources and methods,

alongside more widely adopted discourse analysis techniques, in order to gain insight into the controversial yet important topic of distributed personal underground development.

1.2 Research aims and questions

The main purpose of this study is to understand attitudes towards individual underground development as a social phenomenon of choice (e.g., aesthetics of eco-living, attractiveness of organic design) or necessity (e.g., noise reduction, protection against weather cataclysms). Conceptual mapping of this subject aims to demonstrate which locations may hold the potential for underground development as an alternative or parallel planning direction, based on the degree of social approval for this type of accommodation. The proposed method may serve as a powerful screening tool for public perception, which may precede more immersive types of engagement (e.g., forums or focus group approaches) with urban residents or local authorities (Silva, 2012).

In order to be able to appropriately position the dilemma 'to dig or not to dig' in a planning discourse, it was therefore important for our study to focus on two main aspects: (a) *urban locations*, which have or currently are implementing underground housing projects, and (b) *perceptions*, provoked by the mediated representation of the underground mode of living and degree of readers' engagement with this urban development topic.

1.3 Methodology

Two main sets of methods – linguistic and digital – have been employed in this study. Whilst the first group has already found its niche in the normative tradition of urban planning discipline (Buunk & van der Weide, 2015), the full potential of the second method for planning purposes is yet to be explored (Silva, 2012). When reference is made to digital methods, what is most commonly assumed is the automated processing of structured information, which is not necessarily a complete definition of this approach. Specialists divide techniques into 'natively digital' and 'simply digital', according to the nature of the data sources they are capable of processing (Rogers, 2013b). The 'simply digital' group of methods is usually applicable to datasets which have originated in the analog world (e.g., interviews, reports, old photos) and have been digitized, whilst 'natively digital' methods deal with data which is produced, stored and disseminated in the digital (or cyber-) sphere exclusively. The main dataset used in our analysis was unstructured and hybrid (both 'natively digital' and 'digitized') information contained on the web.

The extraction of both data sources was facilitated by the construction of queries for the Google web navigation engine, the results of which provided links to mixed media sources (blogs, news, individual sites and social media platforms), ordered by Google's PageRank according to the source reputation or item's popularity

(Weltevrede & Helmond, 2012; Rogers, 2013a). The intensity of the social interest and engagement around the research topic of underground development has been tested against two other popular search terms, evolving around the controversial dilemma of self-building in urban settings: ~'buy a house' and ~'build a house' (Figure 1).

The Google search engine was repurposed into a research tool (Rogers, 2013a) by switching to the 'no country redirect' mode and using single queries in the English language only. The query yielded around 500 web sources comprising mixed media (blogs, news links to social media platforms etc.) from which, for the sake of data consistency and the adaptation of digital methods for information extraction, media platforms (e.g., Pinterest and TripAdvisor) were filtered out from the inventory, (see Figure 2).

The initial step in our analysis consisted of gathering information concerning urban underground development projects, including their description and location (city/town and country). To extract descriptive information, the *SentenceRipper* (DMI, 2012b) research tool from the Digital Methods Initiative was used to strip the text content from the list of collected URLs and incorporate these into a database consisting of single sentences as elementary unit entries (Bruns, 2007). Each unit was mined for keywords (DMI, 2012a) and location (DMI, 2014b) to extract semantic information required for our analysis.

To collect data regarding social reaction to projects, the DMI (2014c) research tool was used to detect the most frequently used 'social buttons' on each website,

which was subsequently followed by an application of the DMI (2013), which retrieved the number of 'likes' on Facebook as an indication of the most commonly occurring web 'fingerprint' within the list of returned websites (Geiger, 2015). For each URL entered, the script queried the Facebook Query Language (FQL) API and retrieved the number of 'likes', 'shares', 'comments' and 'clicks'. This information was combined and used in the analysis to illustrate the degree of social engagement with particular underground development projects, as described in the news media, on blogs or on individual websites.

For opinion mining, the *Discus Comment Scraper* (DMI, 2014a) tool was used to extract comments from the list of input URLs and to structure them into an individual database. In a similar approach to the text content analysis, each comment was mined for geolocation (city/town and country) and provided as input for the sentiment analysis routine. We used a naïve opinion mining approach and estimated comments' sentiments by counting the number of occurrences of "positive" and "negative" words (Liu, 2012). To assign a numeric score to each message, we substracted the number of occurrences of negative words from the number of occurrences of positive words. Larger negative scores subsequently corresponded to more negative expressions of sentiment, neutral (or balanced) expressions were net to zero, and very positive comments scored larger positive numbers. Hu and Liu's 'opinion lexicon' was used as a categorization source, containing valuation for approximately 7,000 words and having been successfully validated for English language texts in previous studies (Liu, 2012). Some of the

most useful properties of this lexicon include misspellings, morphological variants and slang processing. The body of the sentiment scores has been normalized to a scale 1-100.

Manual quality checks of the results of the digital tools were performed at each stage of the data processing lifecycle, which was made possible by the reasonable volume of collected information.

2. Visualizing personal underground developments in urban settings

We visualize the values of the development projects, both from the perspective of their owners, and also from the perspective of the virtual audiences, which engaged with the online projects' demonstration. Both sets of results are aggregated at the level of a projects' country of origin and are presented in individual subsections below.

2.1 Defining rationales behind underground development projects: typologies

To discover the rationale behind individual underground developments we primarily looked into two types of new knowledge: firstly, we aimed to understand what types of individual projects of this nature existed and how self-builders interact with their properties (e.g., the primary aim of construction and/or how

much time they spend there); second, to gain insight into the reasons and purposes of why the dwellings have been constructed. Both classifications were derived from the manual data observation and automated keyword extraction from the text bodies of the websites.

2.1.1 Classification by the types of residence

According to the data, personal underground houses are used for permanent living as a main residence (the majority of the underground housing projects) or as a vacation residence, often situated either in suburbs (e.g., Queens, New York, US) or in coastal cities or towns (e.g., Atlantic Beach City, Florida, US) (Figure 3). The results of data mining demonstrated a substantially higher proportion of projects undertaken for personal development, as opposed to those aimed at contributing to the development of an underground public sphere, examples of which could include crowd-funding of underground public green spaces (e.g., Newline Underground Park in New York, US) or the private conversion of abandoned mines into hotels and tourist landmarks (Hobbiton Caves in Matamata town, New Zealand).

The reason for this may be the high costs associated with such projects (seen, for example, in underground housing projects in the UK, Sweden and the Netherlands), as well as interest in lower energy costs associated with the maintenance of the dwelling (examples of which can be found in Iran, Paraguay and Portugal). Secondary residence projects are mainly those situated in suburbs or in green city

islands, where the price of land is affordable and often used for mixed residential and tourist business purposes (examples in the USA, Spain, Poland and Australia).

The civil public sphere of underground development projects are mainly concentrated in countries with rich underground development histories in ancient or medieval times (e.g., Tunisia, Turkey, Peru) or those with forward-looking intentions for development of modern tourist infrastructure (e.g., Shimao Wonderland in Shanghai, China or the Earthscraper in Mexico) (Figure 4).

2.1.2 Classification by the underlying causes for development

Keyword analysis also enabled us to gain insight into the underlying causes for distributed urban underground development projects (Figure 5).

According to the data, the main underlying reason for exploring underground habitat is increased or uncertain energy costs (e.g., Greece, Paraguay, Spain), or personal choice, for example, eco-living with minimal impact on the surrounding environment (e.g., Sweden, Netherlands, France, Canada). Very often, the desire for eco-living is confirmed by combination with sustainable architecture requirements (France, Switzerland, Netherlands, UK), designed in response to the specific climate of the country and often with in-built passive low-energy features, including solar shading (Las Vegas, US), natural ventilation (The Book House, Portugal) and lighting (Holland Park, London, UK): “The horizontal roofline will introduce between 30%

and 50% more light than the equivalent-sized window because of the fact it is horizontal" (Chiswick, London, UK)(McCloud, 2012).

Location is also one of the top reasons to consider building underground in prime urban areas: 'Holland Park is one of London's most desirable areas: we like it because it is quite *villagey*, even though you are in central London; it is also very close to the London parks.' (Holland Park, London, UK) (McCloud, 2012).

The need for space is also one of the most defining factors of the modern living experience. The data analysis revealed that this need is particularly pressing for capitals and mega-cities (e.g., Helsinki, London, Mexico, New York), where growing infrastructure and restrictions to build over ground lead to consideration of alternative spaces for development.

Many personal underground undertakings take place in already pre-developed underground spaces. Abandoned mines and quarries, old bunkers or neglected ancient caves can be successfully repurposed for living conditions (e.g., Coober Pedy in Australia, Matmata in Tunisia or Zhengzhou in China).

Natural cataclysms (such as storms and wildfires) were highlighted primarily in the countries of North America (US and Canada). Very few projects mentioned noise as a reason for digging underground (e.g., town of East Hampton, New York).

2.2 Virtual engagement and sentiments of urban audiences

Virtual engagement and sentiment of urban audiences as quantitative and qualitative traditions in opinion mining are summarized in Figure 6. For the quantitative engagement, the number of Facebook 'likes', 'shares' and 'clicks' have been summarized into a single indicator and aggregated for each country across the whole inventory of comments. The relative sentiment has been averaged across comments and for each country, respectively.

Figure 6 demonstrates that the overall sentiment towards this architectural trend is positive across all countries in this study. It is also the case that no correlation was identified between the engagement activity and the average sentiment score: countries such as France, United Kingdom, Netherlands and the United States demonstrate very high levels of social engagement, coupled with a relatively modest sentiment expression, while Tunisia, Oman and Morocco have more positive attitudes, but an insignificant degree of activity on social media and thus a low expectation of message spread within their urban communities. This finding can, in part, be explained by the differences in cultures of engagement with digital media between these two groups of countries (GWI, 2015).

The highest sentiment scores among countries where urban underground development projects took place were for Tunisia, Italy and Switzerland; however, none of these countries demonstrated particularly active dissemination of the information on social media. As previously discussed, this can partly be explained by the culture of digital engagement; non-English commentary is also likely, but was outside of the scope of the analysis in this study.

Scandinavian countries such as Finland and Norway demonstrate the lowest positive engagement with the prospects for personal underground living. This could be caused by several factors, one of which is linguistic, the manner Nordic people express themselves is less emotional (Warner-Søderholm, 2012), but also geographical, as having long dark seasons already limits citizens' exposure to natural light.

Manual analysis of comments has revealed arguments which can often be overlooked in sentiment analysis, as well as some common misconceptions concerning the underground lifestyle. For example, some personal beliefs (e.g., 'I do not think I could live down that hole') might demonstrate deeply rooted opinions, which are unlikely to change under any type of argument. Some retrospective misconceptions indicate the need for better communication of the design of underground homes (e.g., 'The last thing you want is to use daylight fluorescent tubes. So I specifically light things so you get great shafts of light that give you that contrast between light and shadow'). It is desirable, therefore, to expand the study in due course toward a more detailed analysis of the comments. We plan, therefore, to collect and interpret more personal drivers behind underground development initiatives as part of the self-build movement, which can be of cultural, educational or personal origin.

3. Conclusion

This study provides the first web-analytic-based insight into drivers behind distributed self-build underground projects in urban locations worldwide. Exploiting the principles of information propagation within the web sphere, the study provides preliminary insights into *values* and *opinions* of both *developers* and *observers* in urban environments. Conceptual mapping of this subject explored which locations might hold the potential for underground development as an alternative/parallel planning direction, based on ongoing development in those cities or degrees of social approval for this type of accommodation. We believe that the proposed web-analytic approach is a potentially powerful screening tool for canvassing public opinion on urban planning matters, which can be employed before more immersive types of engagement (e.g., forums or focus groups) with urban residents or local authorities are commissioned.

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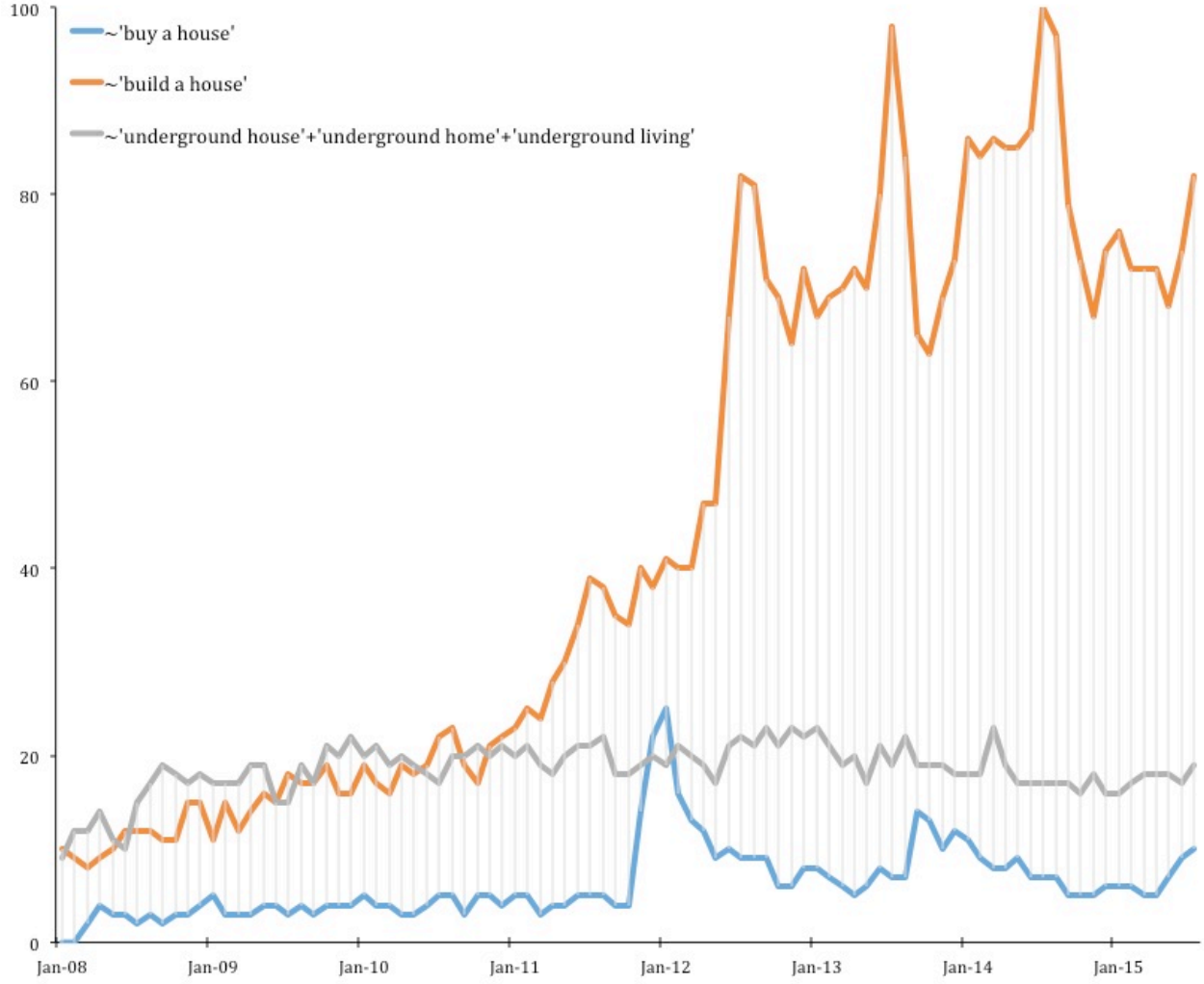

Figure 1. Relative proportion of the search terms to the total volume of queries. Data source: Google Trends

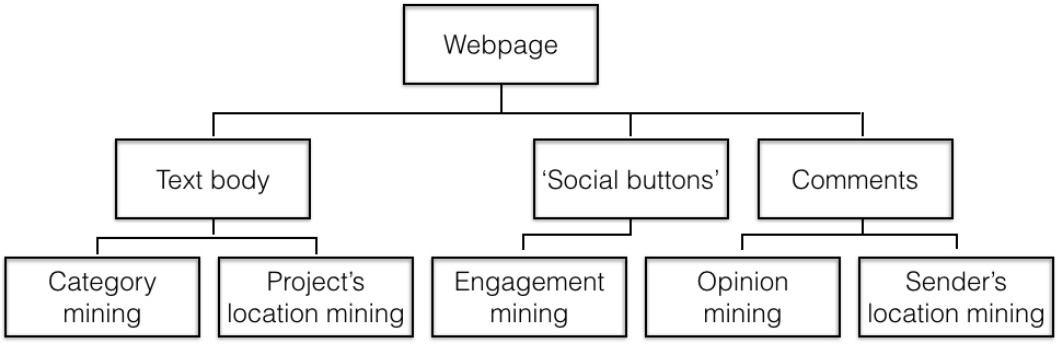

Figure 2. Workflow model

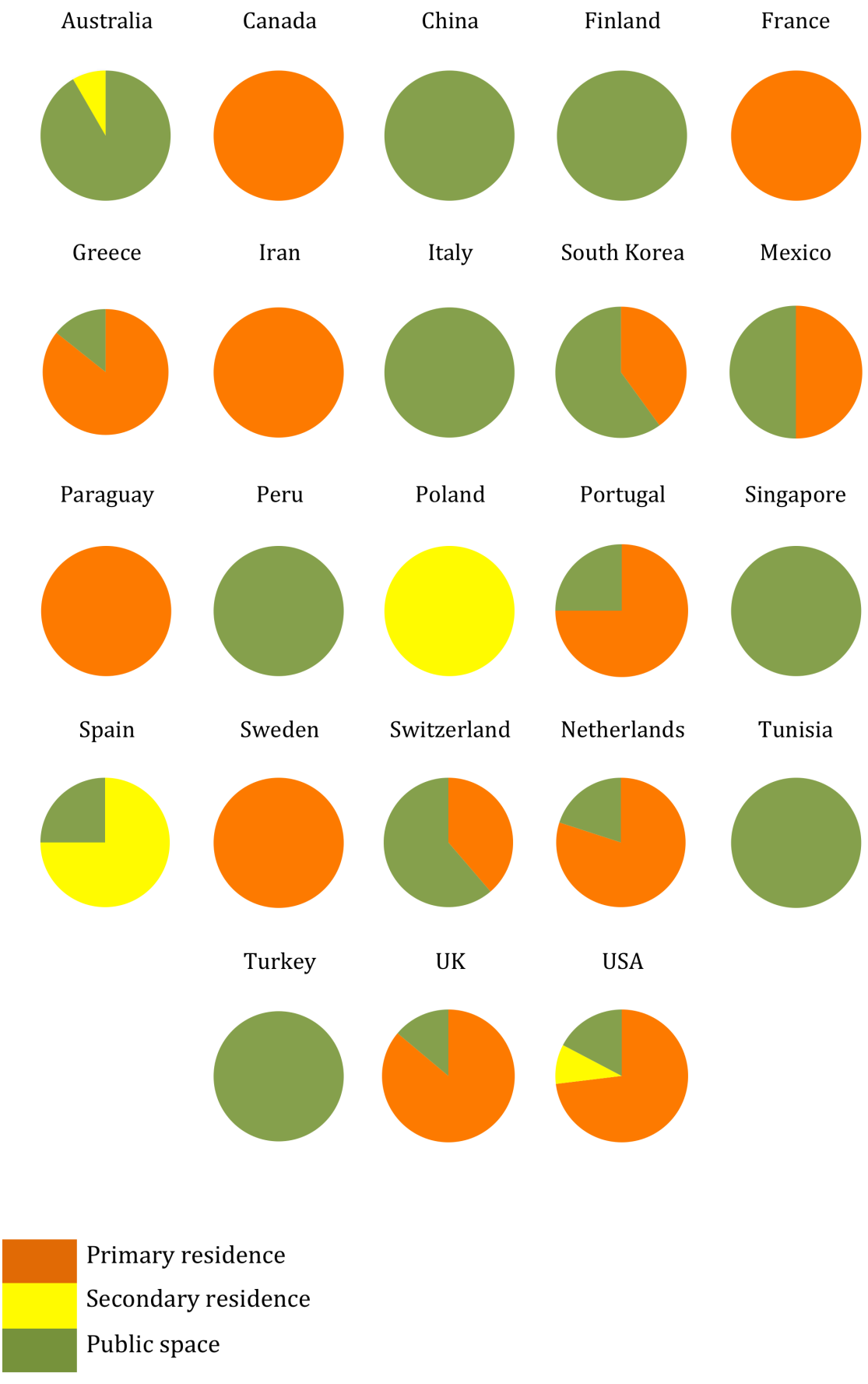

Figure 3. Classification by the residence types

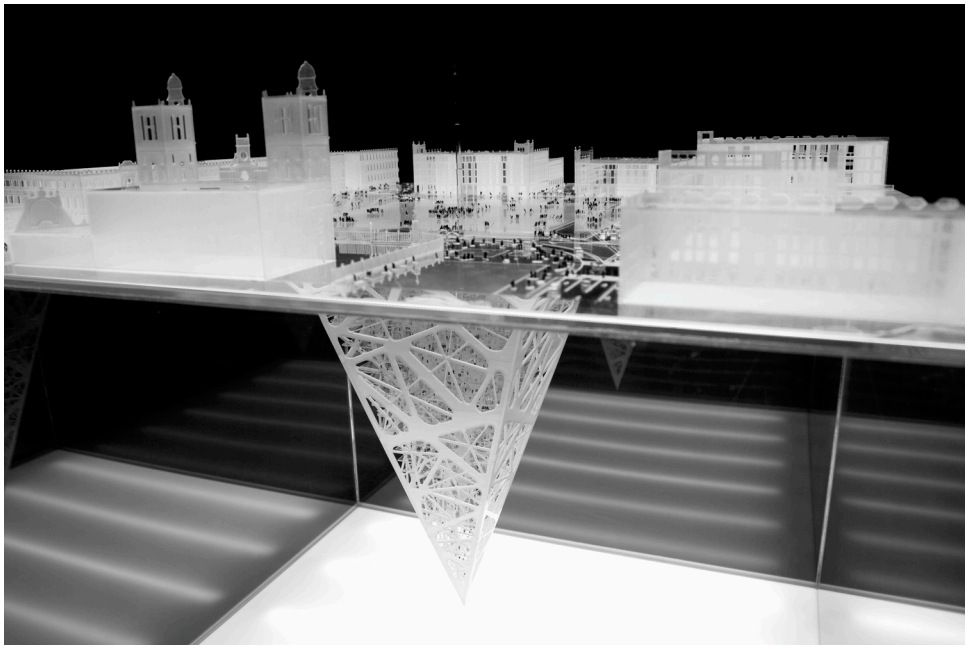

Figure 4. Prototype model for Earthscraper underground development project, Mexico City, Mexico ("BNKP Arquitectura – The Earthscraper model 03.jpg" by ForgeMind ArchiMedia – CC : BY)

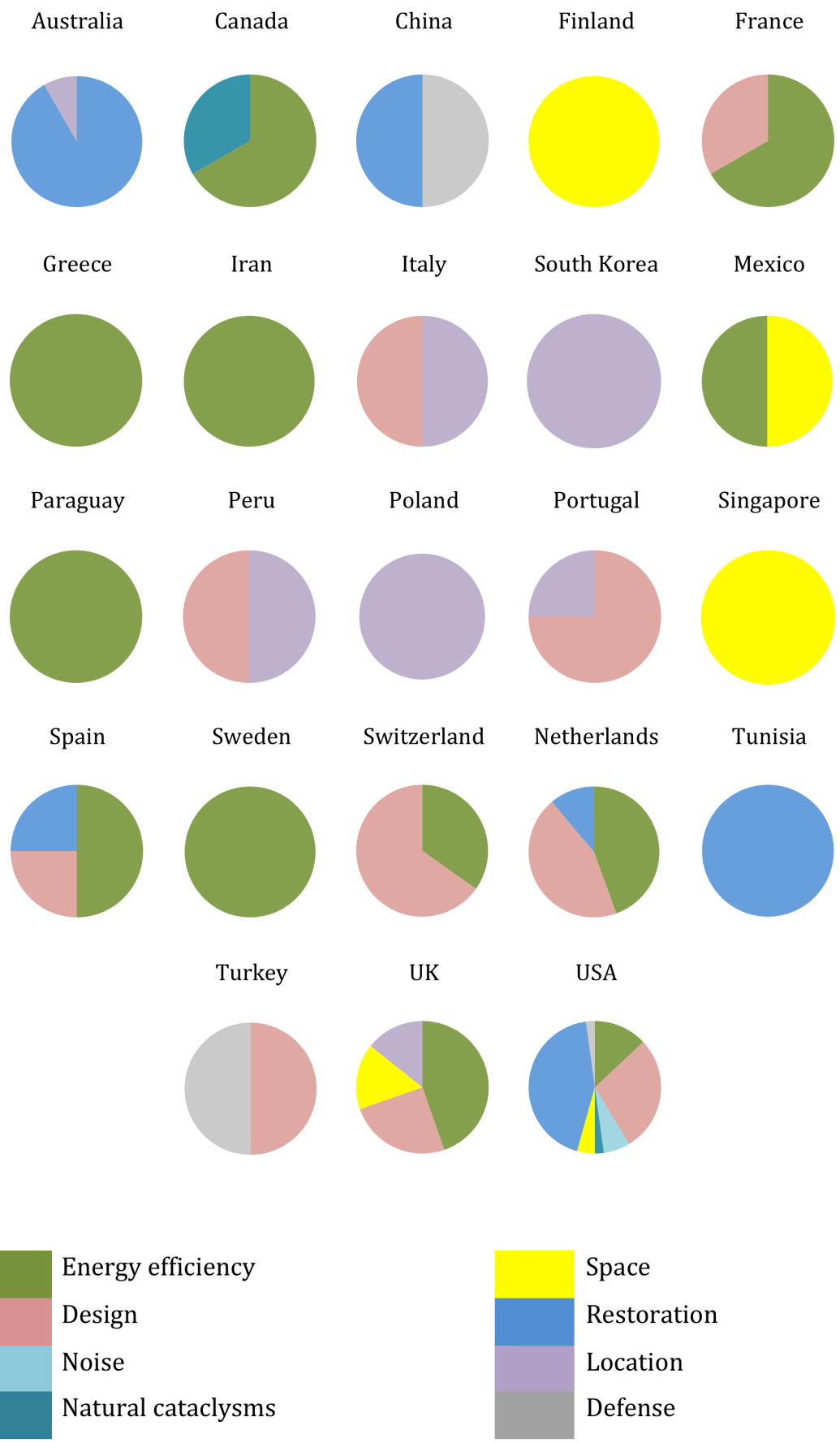

Figure 5. Classification by the underlying development causes

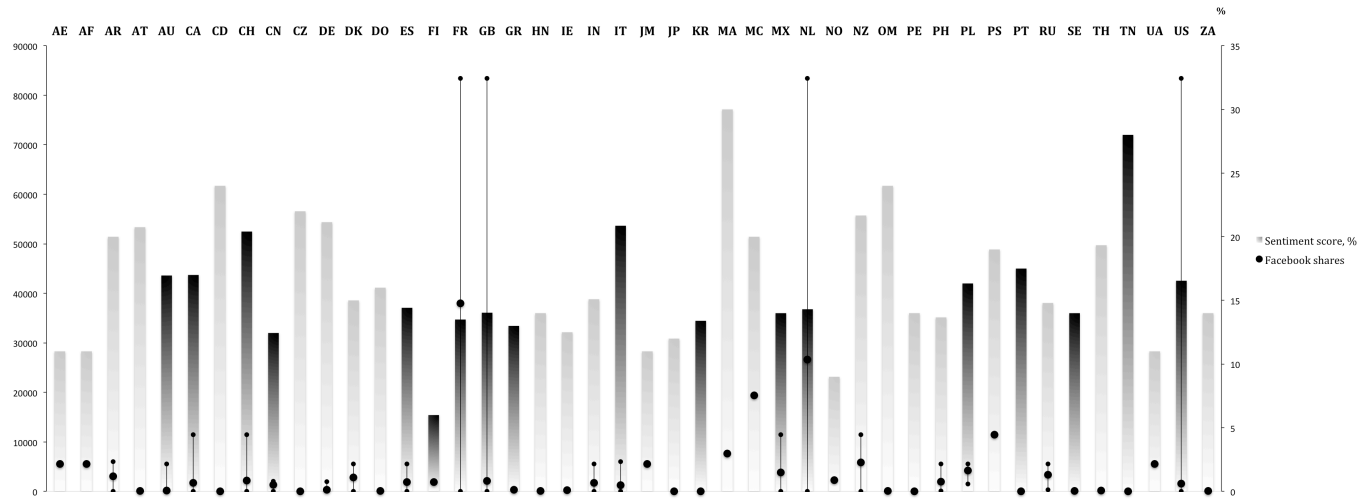

Figure 6. Combined quantitative and qualitative indicators of public engagement with underground development projects on the web (darker bars represent countries where projects took place)