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Beyond the Built-up Form / Mobility Relationship: Spatial Affordance and Lifestyles.

Giovanni Fusco

UMR 7300 ESPACE, CNRS/Université de Nice-Sophia Antipolis
98 Bd Herriot, BP 3209, 06204 Nice, France

Highlights

- The concepts of spatial affordance and dwelling regime (prevailing lifestyle) are defined.
- Within a quantitative approach, indicators are used to describe spatial affordance and dwelling regimes.
- Indicators are calculated for spatial units in the metropolitan area of the French Riviera.
- Bayesian Networks are used to infer typologies of place based on spatial affordance and dwelling regime indicators.
- Cross-analysis of the two typologies is performed and new insight on the study area is gained going beyond the built-up form/mobility relationship.
- All combinations of spatial affordance and dwelling regime types are not possible, as concordance relationships bind these two aspects of place.

Abstract: The aim of the paper is to explore the interplay of spatial affordance and lifestyles within a metropolitan context. The reorganisation of urban regions in integrated metropolitan areas generates new lifestyles based on hyper-mobility (often in the form of car dependency) and poly-topic practice of space. At the same time, the physical and functional characteristics of urban and rural components of space are modified. Within a quantitative approach, spatial indicators are used to describe the different facets of spatial affordance and of lifestyles of the resident population. The case study is the French Riviera metropolitan area, in south-eastern France. The indicators are used within a Bayesian Network model to identify typologies of place in the metropolitan area. Two typologies are produced. The first one identifies seven classes of spatial affordance ranging from regularly planned, dense and mixed urban cores to less accessible peripheral rural villages under metropolitan influence. The second one looks for profiles of place based on the prevalent lifestyles of its population (dwelling regimes). Once again seven classes are determined, including urban, suburban and metropolitan-rural lifestyles. The correspondence between spatial affordance and lifestyles is later explored to compose a more thorough description of places. The research confirms the need to enlarge the view of the built-up form / mobility relationship, shows the usefulness of the concepts of spatial affordance and dwelling regimes and explores new methodologies for identifying profiles of place. The probabilistic framework of Bayesian Networks proves particularly well suited to capture the fuzzy relationship between spatial affordance and lifestyle.

Key-Words: Spatial Affordance, Lifestyles, Dwelling Regimes, Indicators, Bayesian Networks, French Riviera.

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1. Introduction

Research on the relationship between built-up form and mobility behaviours in urban space has a long tradition. Transformations in urban morphology, transportation (and communication) networks and mobility behaviours nourish a vast debate on the contemporary metropolis (Wiel 1999, Ascher 1995, Castells 2002). As far as empirical research is concerned, Newman and Kenworthy (1989, 1998) as well as Kenworthy and Laube (1999) first highlighted the role of urban density in a world-wide comparison of metropolitan areas. According to these authors, population density, measured at the metropolitan scale, shapes both transportation offer and average mobility behaviours of city-dwellers. Their researches were seminal and have given rise to several developments (Naess 1995, Giuliano and Narayan 2003, Van de Coevering and Schwanen 2006) as well as harsh critiques due to the aggregate level of the analysis and the simplified conceptual (and empirical) relations among the phenomena (Gordon and Richardson 1989, 1997, Fouchier 1997). Inspired by Newman and Kenworthy's work, international comparisons at the metropolitan level have thus later been conducted in order to better specify the causal chain of the built-up form / transportation / mobility interaction, and to evaluate its overall performance in a sustainable development perspective (Fusco 2004, Le Nechet 2011). Urban densities, transportation offer and accessibility levels have also been studied at municipal level within a given metropolitan area (Camagni et al. 2002). Cervero and Kockelman (1997) investigate the relationship even more locally, distinguishing the relative role of density, functional diversity and urban design within urban neighbourhoods. The impact of the configuration of street networks on modal choice, and more particularly on walking habits, has also been explored through *ad hoc* surveys (Genre-Grandpierre and Foltete 2003, Rodriguez and Joo 2004). On these bases, planners have identified design strategies to foster or hinder different patterns of mobility behaviours (Boarnet and Crane 2001). More generally, mobility survey data open the way to the analysis of the impact of built-up form on mobility behaviours integrating further socio-economic characteristics of the households (Cervero 2002). At this local scale as well, causal links among variables have been better explored (Bagley and Mokhtarian 2002, Handy, Cao and Mokhtarian 2005, Lin and Yang 2009). Research in this field is so vast, that meta-analyses are proposed to summarise results obtained with different variable definitions, methodologies and study areas. Ewing and Cervero (2010), for example, overview research based on regression analysis of mobility behaviours on built-up form parameters over the last two decades.

Advances of empirical research on the connection between built-up form and behaviours from city dwellers have thus identified elasticities of modal choice and destination preferences for different categories of people, as well as transit-inductive, car-inductive and walking- or cycling-inductive morphological arrangements. We think nevertheless that trying to identify the impact of every form element on people's behaviour (which is the very aim of regression analysis) should not be the only research strategy. The different aspects of built-up form overlap among them as well as with other functional and perceived characteristics of the urban space, contributing to a more general "habitat" or "ecosystem" for urban and metropolitan life. A "habitat" is a systemic view of physical, functional and perceived elements of urban morphology, taking into consideration the mutually reinforcing interactions among elements. The concept of overall physical affordance of a given habitat seems to us an appropriate generalization of the mobility-inductive characteristics of specific form elements. At the same time, mobility has to be placed within the broader context of lifestyles and attitudes of city-dwellers (Kaufmann 2000, 2007, Lanzendorf 2002, Urry 2007). Mobility behaviours are part of more general lifestyles reflecting people's habits, attitudes, values and aspirations in urban space. Econometric models are thus starting to address lifestyle-related mobility patterns (Pinjari et al. 2011). Going back to the debate on the contemporary metropolis, we think that spatial affordance and lifestyles can indeed throw new light on the most recent transformations of urban space. The reorganisation of urban regions in integrated metropolitan areas, often referred to as metropolisation process (Ascher 1995, Lacour and Puissant 1999), gives birth to new lifestyles based on hyper-mobility (often in the form of automobile dependency) and poly-topic practice of space (Stock 2004). At the same time, metropolisation modifies the physical and the functional characteristics of the urban and rural components of space and enlarges the usual perimeters of the urban realm.

1 The aim of this paper is thus to explore the interplay of spatial affordances and lifestyles within a
2 given metropolitan context. The case study of our analysis is the French Riviera metropolitan area,
3 showing important diversity both in physical characteristics and in prevailing lifestyles.
4 The rest of the article will be structured as follows. Section 2 introduces the concepts of spatial
5 affordance, lifestyle, dwelling regime and place. Section 3 presents the case study of the French
6 Riviera and the empirical data of the analysis. Section 4 presents the research methodology, namely
7 spatial indicators and multivariate clustering through Bayesian Networks. Sections 5 and 6 show the
8 results of Bayesian clustering on indicators of spatial affordance and dwelling regime within the
9 French Riviera metropolitan area. Section 7 proposes a cross-analysis of the two typologies of
10 metropolitan space previously identified and explores the empirical correspondence between them.
11 Conclusions, critical assessment and perspectives of future development of the research are presented
12 in Section 8.

13 **2. Spatial Affordance, Lifestyles and the Functioning of Metropolitan Space**

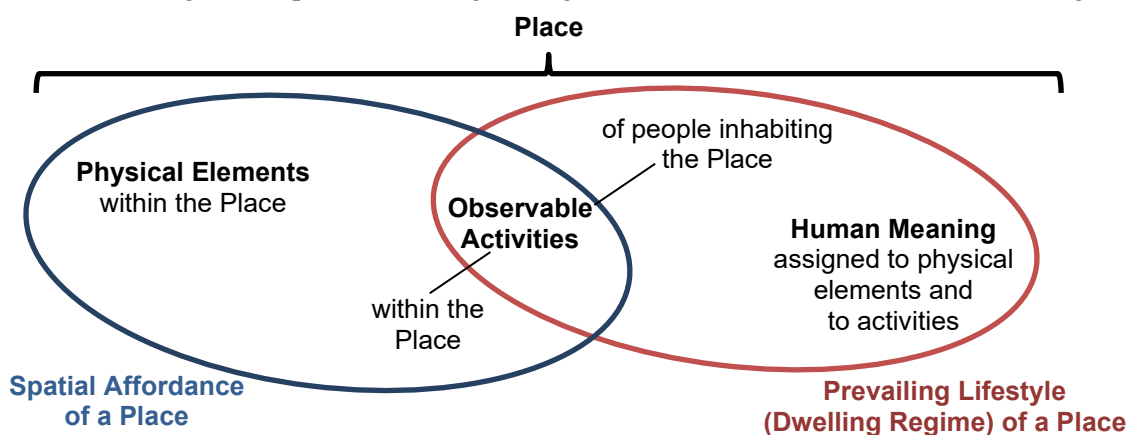
14 The concept of affordance was first introduced by Gibson (1979) in ecological psychology.
15 Affordance is the characteristic of an object to suggest its functionality and use through elements that
16 can be directly perceived from its users. Affordance is not simply a physical characteristic of the
17 object, as it also depends from the task to be performed and from the user's capabilities (Jordan et al.
18 1998). Gibson's definition was later criticised as it relied uniquely on the subject's perception of
19 objects. In real life situations, cognitive processes (both of habitual objects and new ones) play an
20 important role in the subject's ability of projecting possible uses on objects at hand.

21 For the purpose of geographical analysis, we propose the new concept of "spatial affordance". This is
22 defined as the set of task-relevant characteristics of geographic space in connection with "complex
23 tasks", as they emerge from the practice of a whole population. Our research focuses on inhabiting
24 geographic space (Stock 2004), which is a perfect example of a complex set of actions that people
25 perform within or outside of daily routines: dwelling, going to work, shopping, enjoying leisure time,
26 visiting places on weekends, attributing values and meaning to these activities and to the places
27 involved, etc. Inhabiting is not linked to a simple perception of space (as could be the case for space
28 exploration by tourists). It is a more complex knowledge of the possible uses of space that should be
29 considered. Being mainly concerned with inhabiting urban space (or ex-rural areas in a metropolitan
30 context), we will limit our analysis to the aspects of urban morphology that contribute to spatial
31 affordance. If urban form is defined in its broadest sense, covering physical, perceptive and socio-
32 functional aspects, as proposed by Levy (2005), we think that its descriptors are good descriptors of
33 spatial affordance, as far as they convey to its inhabitants different possible uses of urban space,
34 different ways of "doing with it". Appropriate descriptors of spatial affordance should thus include
35 indicators of visible activities, of centrality functions and of accessibility levels in order to supplement
36 descriptors of physical urban form and housing stock.

37 The different ways of performing the complex set of actions of inhabiting geographic space do not
38 combine randomly within a given population, but give rise to particular patterns defined as lifestyles.
39 Lifestyles are socially classifiable systems of practices (Bourdieu 1979). By integrating the spatial
40 dimension of lifestyles (places used to perform activities and mobility needed among them), Stock
41 (2004) proposes the concept of "dwelling mode" (*mode d'habiter*) of individuals and households as
42 being more appropriate than lifestyle in geographical analysis. In what follows we will use them as
43 synonyms, which implies that the spatial dimension will always be fully integrated in the concept of
44 lifestyle. When a lifestyle / dwelling mode becomes predominant among the population of a given
45 territory, we can speak of a "dwelling regime" (*regime d'habiter*), i.e. a dominant model for this
46 population of being in relation with geographic space within a territorial unit.

47 It is tempting to correlate lifestyles and dwelling regimes to the physical and functional aspects of
48 space. This is of course not a simple cause-to-effect relation. Dwelling regimes could be tributary of
49 spatial affordance, and at the same time they could contribute to shape the way space is perceived,
50 used and actually structured by its inhabitants. Place will thus be used as a third, encompassing
51 concept accounting for the association of given spatial affordances and dwelling regimes in a given
52 space. Phenomenologist geographers claim that it is precisely through the meaning conferred by the

1 actions performed in space that space becomes “place”. According to Relph (1976), place is a unique
 2 instance (localised in space) of a pattern composed of physical features, observable activities and
 3 human meaning. In our opinion, “place” can precisely be defined by jointly considering its spatial
 4 affordance and the lifestyles / dwelling regimes characterising its inhabitants (Figure 1). Physical
 5 elements and observable activities within a place are what the spatial affordance of a place is mainly
 6 made of: in order to suggest its functionalities, a place must also show how these functionalities are
 7 actually put in use by people (Jordan et al. 1998). Sidewalks full of people walking or window-
 8 shopping suggest different potential uses than desert sidewalks bordering parking lots, as Jacobs
 9 (1961) already remarked. At the other end of the equation, the observable activities of people
 10 inhabiting the place and the human meaning assigned to physical elements and activities are the main
 11 features of predominant lifestyles (dwelling regimes).
 12 Of course, places are cells within a system of places. A metropolitan area is a rather complex and
 13 diversified system of places, allowing dwelling modes that differently combine the spatial affordance
 14 of its places. This imposes a subtle distinction on the question of observable activities. The spatial
 15 affordance of a given place draws on the observable activities of all the people which are present in it:
 16 residents, city-users, tourists, etc. The intense and diverse urban life of a city-centre is thus not the
 17 result of its residents only. On the other hand, when characterising the dwelling regime of a place, we
 18 are interested in the prevalent dwelling mode of its inhabitants, which could imply mobility within the
 19 whole metropolitan area. A suburban commuting dwelling regime, for example, is not just defined by
 20 the habit of sleeping at night in a peripheral subdivision, but by precise patterns of visiting
 21 employment, shopping and leisure activity centres, often through considerable car mobility, and of
 22 giving meaning to residential peacefulness and to the use of a private garden, as opposed to the use of
 23 public space in city-centres.
 24 The use of the concept of place has nevertheless the implicit danger of suggesting that unique
 25 instances cannot support any generalisation of analysis results. The aim of our research is to overcome
 26 this assumption. We will thus, on the one hand, temper the tendency to reduce dwelling regimes to
 27 explicatory morphological factors. On the other hand, with the working hypothesis of several distinct
 28 classes of spatial affordance and dwelling regimes within a metropolitan area, we will explore the
 29 existence of categories of places, allowing some generalisation on the bases of observable regularities.



30 Figure 1. A conceptual framework for Place, Spatial Affordance and Lifestyle/Dwelling Mode.
 31

32 3. Case Study and Empirical Data

33 3.1 The French Riviera Metropolitan Area

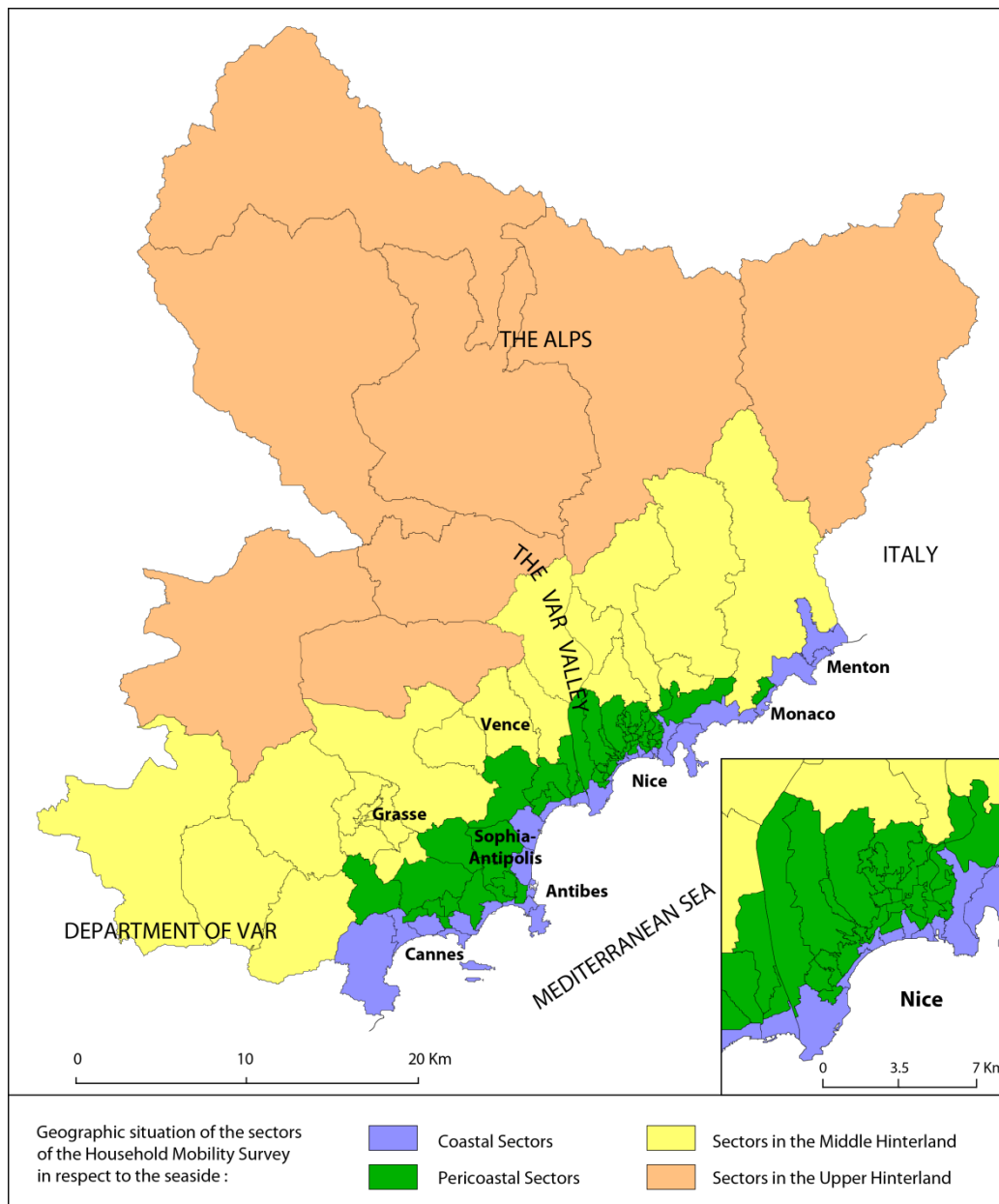
34 The case study for our research is the French Riviera, in South-Eastern France (Figure 2). It is a
 35 polycentric metropolitan coastal region of over one million inhabitants with a strong residential and
 36 touristic economic base. Over the last decades, several coastal cities (Nice, Cannes, Antibes, Monaco)
 37 and a few minor centres in the close hinterland (Grasse, Vence) have coalesced to give birth to a vast
 38 conurbation. New activity areas have also emerged in the interstices of the conurbation, like the
 39 technology centre of Sophia-Antipolis and the activity areas in the lower Var valley. The functional

1 influence of the coastal centres of the conurbation goes well beyond the pericoastal area and
2 encompasses much of the Alpine hinterland, as well as parts of the neighbouring Department of Var
3 (France) and of the Region of Liguria (Italy), defining a vast metropolitan region (Fusco and Scarella
4 2008, 2012, 2013). The gradual emergence of this metropolitan area has been accompanied by changes
5 in mobility patterns of its inhabitants, at different scales and temporal rhythms (Decoupigny and Fusco
6 2009, Fusco and Scarella 2013). Local authorities are just beginning to realise the increasing extent of
7 the metropolitan area and of the on-going transformations of mobility behaviours. The previous
8 household mobility survey of 1998 had already fostered research on our study area. Jourdan (2003)
9 investigated in a qualitative way questions of centrality and of urban form (mainly density and
10 functional mix) in connection to urban governance and automobile dependence. Fusco (2006)
11 proposed a causal analysis of the link between urban form (density, centrality, functional mix),
12 transportation offer and mobility behavior of the resident population. Nevertheless, these works did
13 not address in a more systemic way the association of lifestyles with physical and functional
14 characteristics of space. The latest household mobility survey of 2008-09 is the first to cover the
15 hinterland, as well as the easternmost part of the Department of Var (although it does neither cover the
16 Principality of Monaco, nor Italian municipalities). The survey also covers for the first time items like
17 weekend and residential mobility, along with more traditional themes of daily mobility, motorisation,
18 dwelling and socio-economic characteristics of the resident population.

19 The metropolisation process is not only a change in mobility behaviours. Physical changes in land-
20 cover, urban form, commercial offer and activity distribution are essential factors of the emergence of
21 the new metropolis. The highway network deeply modifies accessibility patterns within the
22 metropolitan area and this, together with mass motorisation, fosters new suburban developments and
23 peripheral retail centres. Old villages and ex-rural scattered settlements are also integrated in the
24 metropolitan system. How are these transformations related to the new metropolitan lifestyles and
25 mobility behaviours? At the same time, the morphological and functional characteristics within the
26 metropolitan area are so diverse (traditional urban fabric, skyscrapers, collective housing projects,
27 suburban subdivisions, old villages more or less accessible from the coast, etc.), just like the
28 observable lifestyles. Is there a link among these two important aspects of metropolitan, observable
29 landscapes, physical and functional features on the one hand, human and social features on the other?

30 The concepts of spatial affordance and of lifestyles/dwelling regimes can be used to answer these
31 questions. Our goal is to identify the variety of places within the metropolitan area of the Riviera.
32 Within this variety we will look for archetypical categories of places, characterised by consistent (i.e.
33 recurrent) patterns of spatial affordance and dwelling regimes of people inhabiting them.

34



1
2 Figure 2. The French Riviera Metropolitan Area

3 3.2 Empirical Data from Multiple Sources

4 In order to conduct a joint analysis of spatial affordance and lifestyles/dwelling regimes, we need
 5 appropriate spatial databases. The 2008-09 Household Mobility Survey (HMS, Conseil Général 06
 6 2009) provides useful information on lifestyles, behaviours, opinions and socio-economic
 7 characteristics of the resident population. Housing characteristics are also described in the database,
 8 but they are far from covering the different aspects of spatial affordance. Other databases have thus to
 9 be used, namely the BD TOPO (issued by IGN, the French National Geographic Institute) a
 10 geographic coverage of the study area including buildings and street network at metric precision. The
 11 affiliation database of the local chamber of commerce is also used to characterise retail offer. National
 12 Census, both in France and Monaco, as well as the *Monaco en chiffres* publication series (Principauté
 13 de Monaco 2009), is finally used to quantify items beyond the coverage area of the HMS. The 2008-
 14 09 HMS was in fact conducted over 104 survey sectors, 94 of which in a 15 km wide, 50 km long
 15 band going from the coast to the middle hinterland. In these sectors, 7539 households were surveyed
 16 through a face to face protocol covering all the items of the enquiry. In the 10 most peripheral sectors
 17 (upper hinterland and Department of Var), 1461 households were interviewed by telephone over a

1 smaller number of items. The Principality of Monaco was not covered by the survey at all, but we
2 integrated it in our 105 sectors study area, given its fundamental role in the functioning of the
3 metropolitan area. The combination of all our sources provides a database of several thousand
4 variables covering a much wider spectrum of themes than the one necessary to our analyses. How can
5 we transform this huge quantity of data into valuable information?

6 **4. Research Methodology: Spatial Indicators and Bayesian Networks**

7 **4.1 From data to indicators**

8 We clearly need a way to reduce the dimensionality of our possible analyses. This feature selection is
9 theory-driven and has been structured as follows. First, the two concepts of spatial affordance and of
10 dwelling regime have been defined as the composition of more specific facets. Geographic situation
11 in the metropolitan area, built-up morphology, street network morphology, functional morphology
12 (observable patterns of activity), accessibility and housing were thus identified as the main
13 components of spatial affordance; socio-demographic characteristics, daily mobility behaviours,
14 weekend mobility behaviours, residential choice, motorization, opinions and attitudes as the main
15 components of dwelling regimes.

16 In order to operationalize the description of these components, indicators were calculated for every
17 spatial unit. An indicator is a tool capable of conveying information in a synthetic form on a
18 phenomenon which is more complex and has a wider meaning (Meadows 1998). In its simplest form it
19 is a parameter, or a combination of measured parameters, which is particularly significant in order to
20 understand a phenomenon. Twenty-seven and forty-six indicators have thus been selected and
21 calculated to describe spatial affordance (Appendix A) and dwelling regimes (Appendix B),
22 respectively. In describing spatial affordance, for example, we selected aspects of urban form which
23 are often mentioned in literature to be task-relevant for housing choice, mobility behaviours and other
24 spatial practices of city-dwellers (indicators 4 to 12 in Appendix A). Jacobs (1961), Hillier and
25 Hanson (1984), Hillier (1996) and Habraken (1998) highlight how street network connectivity can
26 influence urban life in connection to human perception of urban space. The relative importance of
27 tree-like structures and of densely meshed networks seem particularly relevant in shaping residential
28 suburban use of space and city-centre mixed use of space, respectively. Instead of using complex
29 indicators of space syntax (as proposed by Hillier 1996), we measured the relative importance of dead
30 ends and crossroads, as well as the average network density within the built-up area (vascularisation
31 indicator) and the local reach of built-up elements (Sevtsuk and Mekonnen 2012). Straightness of
32 connections has been fought by the Garden City movement as incompatible with residential
33 peacefulness and picturesque cityscapes (Hall 2002) but is now recognized as a central feature in space
34 syntax approaches (Hillier 1996). Distances between built-up elements are also paramount in urban
35 proxemics (Hall 1966, Habraken 1998). Lynch (1960) highlights how connections, direct view-lines
36 and spacing shape the perceived cityscape fostering of hindering a sense of place. Architects of the
37 typo-morphology school (Caniggia and Maffei 1979) show how these parameters are the product of
38 given urban cultures and are recognized as such by city dwellers. Land coverage ratio, functional
39 density and built-up density are all commonly used indicators when studying urban form in connection
40 to urban life, perception of urban space, residential choices and mobility behaviours (Jacobs 1961,
41 Cervero and Kockelman 1997, Fouchier 1997, Newman and Kenworthy 1998). More particularly,
42 Berghauser Pont and Haupt (2010) identify land coverage ratio, built-up density and street network
43 density as the three most important urban form descriptors to understand the performance of built
44 landscapes.

45 The selected 73 indicators are descriptors of each of the 105 spatial units of the metropolitan area.
46 They can thus describe the average value of a given parameter for the population within a spatial unit
47 or, much more often, in order to avoid the filtering power of averages, they quantify the proportion of
48 a given behaviour or of a given morphological characteristic within the spatial unit. Of course, the use
49 of quantitative indicators inevitably reduces and simplifies the complexity of the underlying concepts
50 (both spatial affordance and dwelling regime). Nevertheless we see this as a necessary price to pay in
51 order to bridge qualitative conceptual analysis and quantitative spatial analysis.

4.2 Bayesian Network Clustering

The 73 indicators used to describe spatial affordance and lifestyle/dwelling regime are the starting point of a new kind of computer-aided data mining application. Thematic maps of indicators show both redundancy and complementarity among them. Some data are missing, as all indicators cannot be reconstructed for the sectors not fully covered by the face to face survey protocol. A few indicators are qualitative (like the geographical situation within the metropolitan area and the typology of spacing in the built-up fabric). Finally, the indicators are only operational measures of different aspects of two complex concepts: spatial affordance and lifestyle/dwelling regime. As a consequence, any operational description of these concepts through indicators is intrinsically imprecise, sometimes incomplete (not all aspects of the concepts could actually be measured) or contradictory (when indicators point in different directions), in a word uncertain. Uncertainty has thus to be a guiding principle in data mining, both in modelling algorithms and in the interpretation of their results.

In this context, Bayesian Networks (BN) offer an interesting approach for data mining in our database. At the junction between multivariate statistics and artificial intelligence, BN (Pearl 2000, Jensen 2001, Korb and Nicholson, 2004, Pourret *et al.* 2008) are powerful modelling tools in a context of uncertain knowledge. BN were thus used to achieve uncertainty-based multivariate clustering in our database.

In our research design, the clustering protocol has been applied twice: first, to analyse indicators of spatial affordance, and then to analyse indicators of lifestyle/dwelling regime. The guiding principles of this application have already been presented in a prototypical application by Fusco and Scarella (2012). To sum up, the clustering protocol is structured in several phases, coupling supervised and unsupervised learning from the database. The protocol was implemented using the BayesiaLab software (Bayesia 2010).

Step 1 – Unsupervised Learning of Associations. The first step is the search of probabilistically strong links among the 27/46 indicators through unsupervised learning of a BN, a classical knowledge discovery application. At this stage, no previous knowledge is entered by the modeller over the BN structure. Despite the small size of the databases (105 records), the SOPLEQ learning algorithm (Jouffe 2002) produced two networks containing fairly robust links from a probabilistic point of view. Given the small data sample, robustness was assessed through 10-fold cross-validation analysis. Even if the BN learning produces a directed graph, no causal interpretation is needed for such a model. The BN just summarizes probabilistic associations among indicators.

Step 2 – Variable Segmentation. The two resulting BN define probabilistic distances among variables in terms of mutual information (a classic information theory distance measure between two probability distributions, MacKay 2003). They can thus be analysed by a hierarchical clustering algorithm to detect groups of closely linked variables, which can be ascribed to a more general concept. These are intermediate concepts between the 27/46 individual indicators and the two main concepts of spatial affordance and dwelling regime. Six variable groups could be identified for spatial affordance, reflecting the following concepts: accessibility, geometrical characteristics of the street network, built-up density, housing characteristics, centrality and built-up/network connection. Eight intermediate concepts emerge in the characterization of dwelling regimes: motorisation and opinions about motorisation, daily routines, weekend mobility, modal behaviours within the week, priorities for transportation policies, proximity practices during the weekend, non-constrained mobility and attraction by metropolitan centres. These variable groups correspond only approximately to the components identified *a priori* to organise the database: information embedded in empirical data is used to make variable groups emerge in a bottom-up approach.

Step 3 – Determining Synthetic Factors. Latent non-observable variables (factors) are created in order to summarize the information contained in every group of indicators. The number of factor values is automatically determined by segmentation algorithms according to a likelihood maximization approach within a clustering naïve BN architecture. Factors are good summaries of the probabilistic information of the variables: table contingency fit lies between 67% and 89% for 15 of the 16 groups of variables. Individual records of the database can be assigned to values of each factor with very limited uncertainty (always less than 0.05 for dwelling regime and 0.10 for spatial affordance). Links among variables contributing to each factor and high mutual information between variables and factors also make factors robust to addition/suppression of indicators.

1 **Step 4 – Identifying Profiles that Summarise Factors.** A Bayesian classification of individual
2 records (spatial units) can now be performed using the factors. For each clustering application, a new
3 non-observable variable is added, the spatial affordance of place and its dwelling regime, considered
4 to be the latent causes of the six or eight factors, respectively. Once again, the number of profiles is
5 determined automatically through likelihood maximization. Seven profiles can thus be identified
6 within the French Riviera, both in terms of spatial affordance and of dwelling regime. They resume
7 80.2% and 72.2% of the probabilistic information of the 6 and 8 factors, respectively. The
8 determination of the optimal number of clusters by the search algorithms is indeed driven by a few
9 parameters entered by the researcher. Clusters are relatively insensitive to the minimum average
10 probability in assigning units (this value was set to 0.9 but the same results are obtained increasing it
11 to 0.95 or decreasing it to 0.8). On the contrary, clusters were constrained to group at least 5% of the
12 spatial units, in order to attain a certain generalization. Had this threshold been lowered to 2% or been
13 set to zero altogether, we would obtain several more clusters, some of which only grouping very few
14 (eventually one) units. Profile interpretation from factor values is nevertheless unpractical. It will be
15 done in the next step of the analysis using the original variables.

16 **Step 5 – Characterizing Profiles.** Supervised learning of two new BN is now performed in order to
17 characterize profiles of spatial affordance and dwelling regime from the original data plus the newly
18 determined profiles. It is finally possible to interpret the place profiles in terms of probabilities of the
19 combination of values of the original variables. The new BN (having naïve architecture) can precisely
20 be used to infer the characteristics of each profile probabilistically. Profiles don't explain equally well
21 all variables. The latter can then be ranked with respect to mutual information with profiles. Statistical
22 significance is evaluated through a G-test on empirical data. Assuming a 0.05 significance level, only
23 2 variables only out of 27 for spatial affordance and 6 variables out of 46 for dwelling regime have no
24 significant relations to the clusters. These are rather encouraging results (almost all *a priori* selected
25 variables are significantly associated with *a posteriori* identified clusters), but we cannot exclude that
26 other crucial variables are missing in our feature selection (we can only hope that they would at least
27 partially overlap with the selected ones in terms of mutual information).

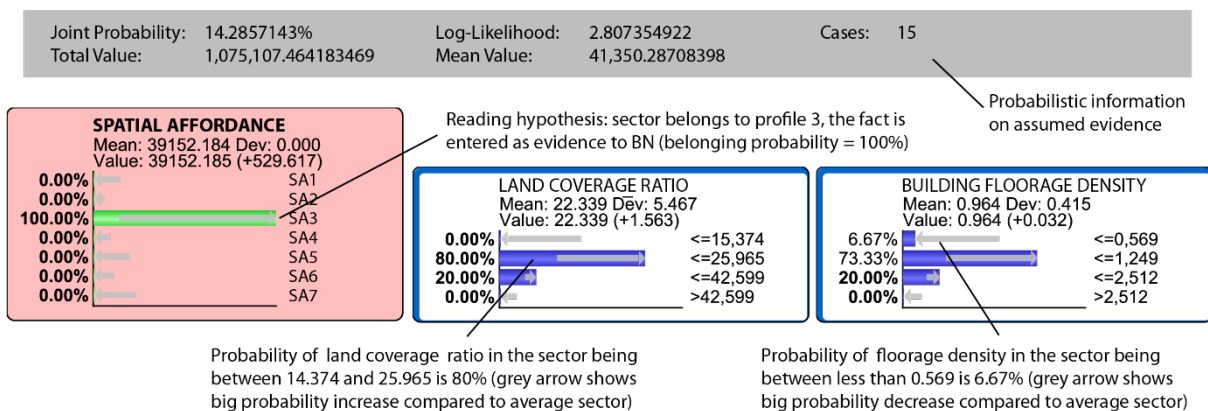
28 The final result of the Bayesian multivariate clustering is thus a double segmentation of metropolitan
29 space. At this level of detail and complexity (105 spatial units, 73 variables), these segmentations
30 could not have been produced by geographical expertise only. It is worth comparing our Bayesian
31 method to more classical factor analysis, with subsequent clustering algorithms (hierarchical or k-
32 means). First of all, intermediate concepts interpretation is much easier than in classical factor
33 analysis: we don't have to interpret linear combinations of empirical variables, but just disjunctive
34 groups of variables. Secondly, interpretation of intermediate factors is not crucial to our analysis. The
35 main goal of summarizing groups of variables in synthetic factors is to avoid information redundancy:
36 factors will contribute equally to the learning algorithm of step 4, regardless of the number of empiric
37 variables they summarize. Thirdly, the main difference with classical clustering algorithms (whether
38 they are performed on empirical variables or on factors) is that these methods try to identify
39 homogeneous clusters based on a multivariate distance function from the cluster centres (however
40 these are defined). This forces units belonging to a given cluster to have more or less the same values
41 on all indicators. On the contrary, Bayesian algorithms maximize cluster likelihood given the
42 empirical data. With this procedure, every cluster is identified by the fact that its members share a few
43 common properties on a subset of variables (and these variables could be different from cluster to
44 cluster). Preferring clusters sharing common properties over homogenous clusters is a crucial choice
45 of our research design: spatial affordance is context dependent (inhabitants of a given area could be
46 attentive only to a subset of the characteristics of this space) and dwelling modes, too, are normally
47 defined by changing subsets of human and behavioural variables.

48 Finally, in all the phases of the analysis, BN have the advantage of a Bayesian probabilistic approach
49 well suited to capture uncertainty issues. Knowing empirical data (and eventually not knowing them
50 completely given the missing data), BN can calculate the most probable clusters (both in number and
51 content). Sensitivity analysis shows that the addition/removal of a single indicator does not alter the
52 segmentation. At the same time, always within a probabilistic framework, it is possible to study the
53 association of every indicator to clusters as a whole and to every single cluster in particular. Affecting

1 a single spatial unit to a cluster is also done probabilistically. We can thus evaluate the uncertainty in
 2 affecting a spatial unit to a cluster, and identify those sectors, which are “between profiles”.
 3 One of the main shortcomings of the Bayesian models, compared to classical regression, PCA or
 4 clustering models, is the need to work with discrete variables. Continuous variables in our database
 5 were discretized in 4 classes using a k-means algorithm. The resulting models are thus relatively
 6 coarse, compared to the precision of classical regression or PCA models. This coarseness is the price
 7 to pay for statistical robustness: discretizing variables more finely would have increased more than
 8 linearly the number of probability parameters to estimate from data.

9 5. A Typology of Spatial Affordance

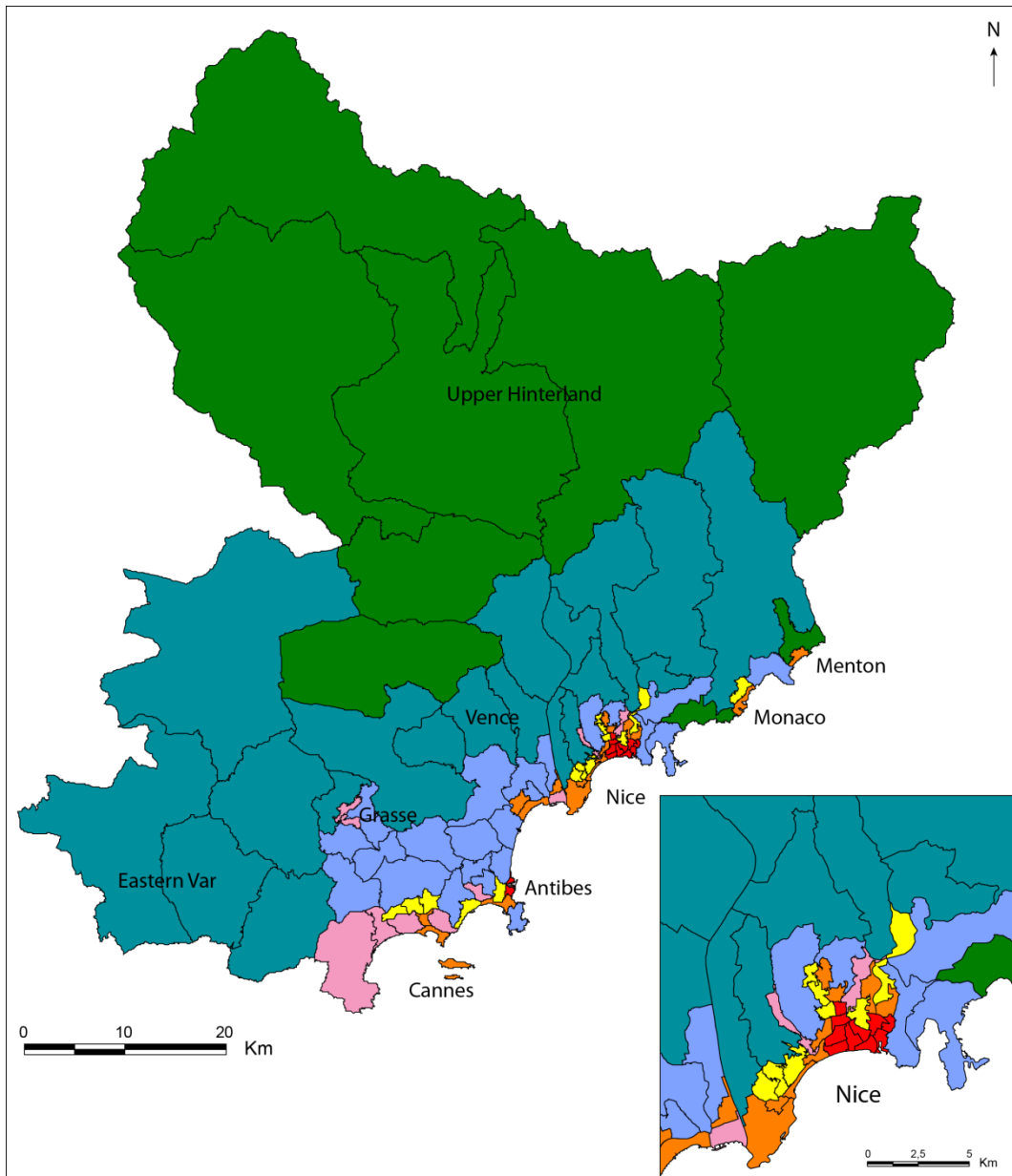
10 BN clustering algorithms identify seven profiles of places in terms of spatial affordance on the French
 11 Riviera. Projected in space, the belonging to the profiles regionalises metropolitan space (Figure 4).
 12 Profiles are commented in what follows, based on their projection in space and on the probability
 13 distributions of the most important indicators (in terms of mutual information with the profile).
 14 Probabilistic profiles of spatial affordance are shown in Appendix C. Figure 3 indicates how to read a
 15 profile. For the sake of a fluent commentary, we will avoid to constantly quote probability values
 16 inferred by the BN model. As a consequence of this editorial shortcut, we will lose some of the
 17 probabilistic nuances of BN clustering.
 18



19
 20 Figure 3 – Bayesian probabilistic reading of a profile.

21 Profile SA1: Planned urban cores with meshed, dense and old urban fabric

22 This profile encompasses 11 sectors which are particularly central within metropolitan space.
 23 Morphological indicators play an important role in characterizing spatial affordance. Urban fabric is
 24 very dense both in terms of land coverage ratio and in building intensity. Street networks are
 25 characterised by frequent intersections, dead-ends are rare, straightness is high: relatively regular
 26 planned grid-based urban forms make up this profile, with high levels of local accessibility, suitable to
 27 walking and cycling. This, together with high centrality levels and contiguity among sectors, results in
 28 high accessibility levels to jobs and schools, both on foot and by transit (a bit less by car). These
 29 sectors are full of urban life, being visited by large numbers of city-users during working days, even if
 30 slightly less during the weekends. Housing offer is typical of French city-centres: a great majority of
 31 collective housing, in old buildings with few big flats and mainly for rental. Sectors in this profile
 32 correspond to the city-centres of Nice and Antibes. In Nice, the profile includes pericentral
 33 neighbourhoods, too, which share the physical elements of affordance, but not always the observable
 34 activities (lower commercial density and presence of city-users). This core of “urban places” in Nice
 35 corresponds to the area influenced by the plans of *Consiglio d’Ornato* (Graff 2000) in the 19th century.
 36



Profiles of Spatial Affordance

- SA1 (11 sectors): Planned urban cores in Nice and Antibes, with meshed, dense and old urban fabric
- SA2 (17 sectors): Centres and pericentral extensions with dense but irregular urban fabric
- SA3 (15 sectors): Peripheral, mainly residential, irregular urban fabric
- SA4 (10 sectors): Pericentral, discontinuous, residential or mixed urban fabric, with varied housing
- SA5 (24 sectors): Pericoastal suburban fabric with high road accessibility
- SA6 (19 sectors): Residential, mainly individual-home suburbs with low accessibility in the middle hinterland
- SA7 (9 sectors): The upper hinterland with distant, difficult to access villages and mixed housing

1
2 Figure 4 – A typology of spatial affordance in the French Riviera metropolitan area.

3 **Profile SA2: Centres and pericentral extensions with dense but irregular urban fabric**

4 This profile concerns 17 coastal/pericoastal sectors, strongly characterised by morphological
 5 indicators. Like sectors of profile SA1, they present relatively dense urban fabric (both in terms of
 6 land coverage ratio and built-up density). Functional density and road accessibility to jobs and schools
 7 are also high, and presence of city-users in the typical working day is high (much less during
 8 weekends). Prevalence of big collective housing is once again a very likely pattern. Like in other
 9 central or pericentral sectors, big flats are underrepresented, small flats overrepresented, the rental
 10 offer is important. The urban fabric is mainly continuous, sometimes mixed continuous/discontinuous.

1 Unlike profile SA1, street network morphologies are more irregular, as the planning effort on these
2 sectors has been less intense. Geographically, these sectors are either the first extensions of the city-
3 centres (in Nice, Antibes, Menton) or city-centres where the planning of urban forms has only
4 concerned scattered fragments (Cannes, Cagnes-sur-Mer, Monaco).

5 **Profile SA3: Peripheral, mainly residential, irregular urban fabric**

6 This profile encompasses 15 sectors around the main urban centres and close to the seaside. They
7 adjoin sectors of profile SA2, but their physical differences with planned urban cores (profile SA1) are
8 even bigger. Sectors in profile SA3 are still relatively continuous, or mixed continuous/discontinuous.
9 But they are more irregular, less vascularised and less dense than profiles SA2 and SA1. Big collective
10 housing represents the majority of main homes, but is not as predominant as in profiles SA2 and SA1.
11 Small flats become a bit less common. What distinguishes the most profile SA3 from profile SA2 is
12 that sectors here are by no means central places, neither in working days, nor in weekends. They are
13 mainly residential places, with very weak retail offer. Some variety characterises the profile:
14 peripheral neighbourhoods in Nice and Cannes are marked by big collective housing; in and around
15 Antibes individual homes are very frequent and big collective housing is limited to 40% of the housing
16 stock. Similarities in spatial affordance can also mask different social content: among peripheral
17 residential sectors in Nice we find both upper-middle class and working-class neighbourhoods.

18 **Profile SA4: Pericentral, discontinuous, residential or mixed urban fabric, with varied** 19 **housing**

20 This profile groups 10 sectors and is another possible issue of the morphological and functional
21 gradient from profile SA1 to profile SA2: SA3 is morphologically closer to SA2, but SA4 shares some
22 of its functional characteristics. Within profile SA4, mixed urban-suburban fabrics are only
23 moderately dense and mainly discontinuous, even if a few dense and continuous cores can be
24 highlighted. Big collective housing is still very present and built-up density is medium to low. Overall,
25 the housing offer mirrors the average characteristics of the study area, showing a mix of collective and
26 individual housing, small, big and medium-sized dwellings, for rental and owner-occupied. Most of
27 this housing stock was built in the post-war decades and in the 1980s (especially suburban
28 subdivisions). SA4 sectors show medium levels of metropolitan usage and centrality, at least during
29 the typical working day. They are thus functionally mixed, sometimes with a residential
30 predominance, but they are never dormitory communities, like SA3 sectors. Like for profile SA5, car
31 accessibility to jobs and schools is relatively good. Geographically, profile SA4 includes peripheral
32 sectors in the big coastal cities (Nice, Antibes, Cannes), emerging new suburban centres or declining
33 old city-centres (as in Grasse).

34 **Profile SA5: Pericoastal suburban fabric with high road accessibility**

35 With its 24 sectors, this profile (together with profile SA3) characterises most of the pericoastal
36 region. Some sectors within profile SA5 are nevertheless coastal or on the southernmost fringe of the
37 middle hinterland. Morphological indicators are essential in characterising profile SA5. Its sectors
38 show typical suburban fabric (eventually interspersed with urban fragments), mainly discontinuous,
39 sometimes even scattered, with low density and limited land coverage ratio. Local building
40 accessibility for pedestrians is low to medium, as a consequence of low density, low vascularisation
41 and generalized presence of dead-ends in the street network. The housing stock has some prevalence
42 of big dwellings, mainly in individual homes. Accessibility to jobs, schools and commerce is relatively
43 mediocre by transit, but is good to extremely good by car. This is the combined result of relative
44 proximity to coastal cities, good highway links and *in situ* presence of business areas (Sophia-
45 Antipolis, Plan-de-Grasse). Some sectors are more definitely residential: on the coast or in suburban
46 areas around Nice, Antibes and Grasse.

Profile SA6: Residential, individual-home suburbs with low accessibility in the middle hinterland

This profile concerns 19 sectors, almost exclusively in the middle hinterland. The situation plays an important role in characterising the profile, together with accessibility, housing and morphology. Sectors have typical suburban fabric, low or very low density and are made up mainly of individual houses, with very limited rental offer. Low density and strong presence of dead-ends in the street network, together with weak vascularisation, produce very low local accessibility levels for pedestrians. Settlement patterns can include several cores (villages, subdivisions or clusters of houses) separated by agricultural/natural areas. Functional density is low (with a few exceptions in the lower Var valley). Accessibility to jobs, schools and commerce is very limited by transit, and mediocre even by car, making a clear difference from the other suburban profile (SA5). Once again, sectors in the lower Var valley are an exception, having better transit/highway links and important job and service concentrations. Geographically, this profile defines a very homogeneous peripheral metropolitan belt, covering the middle section of the main valleys and a few peripheral sectors in Nice.

Profile SA7: The upper hinterland with distant, difficult to access villages and mixed housing

This last profile is made up of only 9 sectors. Just like profile SA6, the situation is fundamental in order to characterise the profile, together with accessibility and housing indicators. The profile concerns sectors with extremely rough topography, mainly in the upper hinterland and exceptionally in the eastern Riviera. Accessibility to jobs, schools and commerce is typically very low, both by transit and by car (but in the coastal sectors). The housing stock is less peculiar than in profile SA6. The built-up fabric is less dense, with low levels of local accessibility, but individual housing is not prevalent and the size distribution of the dwellings is relatively balanced. This profile is also the most mixed in terms of housing offer (for ownership, for rental on the market, social housing, etc.). The majority of dwellings were built before the war, especially in the old villages. Villages, linear urbanisation along valley roads and a few more recent subdivisions, separated by natural areas are the main landscape pattern. Despite the presence of village cores, functional densities are among the lowest in the study area. A few sectors become important leisure centres during the weekend, attracting many city-dwellers from the coast for outdoor activities.

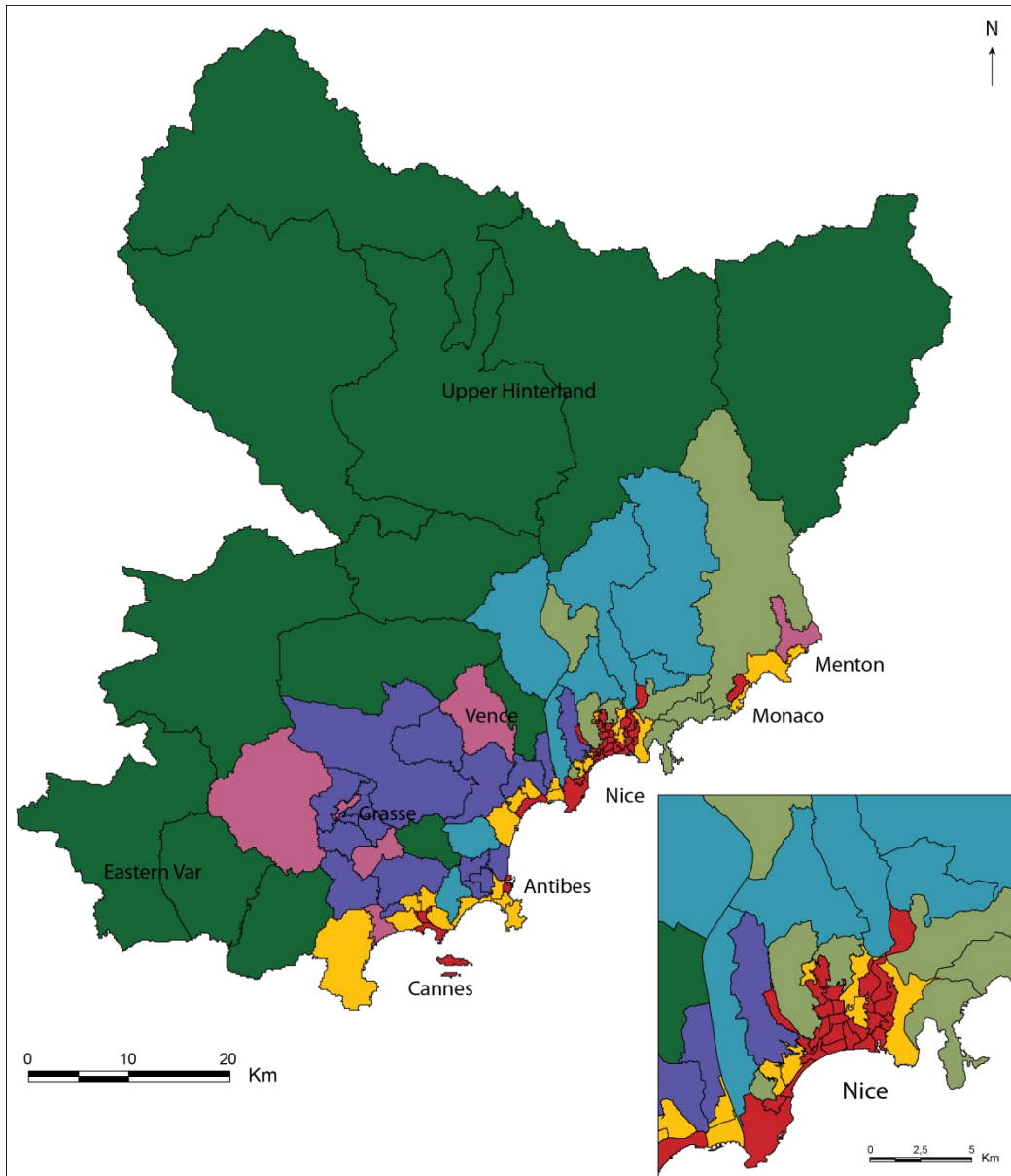
BN algorithms assign individual sectors to the different profiles with extremely low uncertainty (around 0.01). Only four sectors were assigned to a profile with non-negligible uncertainty (0.1 to 0.3). Uncertainty has a spatial structure: affected sectors are mainly around Antibes and show some proximity between the two pericoastal profiles SA4 and SA5.

The regionalisation induced by this typology of spatial affordance in the French Riviera shows that the coastal and pericoastal regions are a mosaic of places of very different kinds, making up the most heterogeneous section of the metropolitan area. On the contrary, almost all the upper hinterland is grouped in the same profile, just like the middle hinterland (with the exception of its southernmost fringe). A profile of residential sectors, with suburban fabric and high car accessibility, is strongly present in the metropolitan area, mainly in the western section of the Riviera. Finally, a double gradient of typically urban spatial affordances characterises the sequences SA1-SA2-SA3 and SA1-SA2-SA4, with a steady decrease in density, regularity of the urban fabric, centrality and functional mix (in the first sequence), density, regularity of the urban fabric and characteristics of the built-up forms (in the second one). Overall, the further from the seaside the more the situation in relation to the coast plays a role in structuring spatial affordance. Closer to the coast, distances from the city-centres and the highway become more crucial factors. Will these spatial structures also emerge in a typology of lifestyles/dwelling regimes? The next section will deal with this second important aspect of place.

6. A Typology of Dwelling Regimes

Even for lifestyles/dwelling regimes, BN clustering algorithms identify seven profiles of places on the French Riviera. More precisely, profiles define dwelling regimes of metropolitan sectors, that is

1 predominant lifestyles within their resident population. Once again, the belonging to the different
 2 profiles regionalises metropolitan space (Figure 5). Probabilistic profiles of dwelling regime are
 3 shown in Appendix D and will be commented in what follows.
 4



Profiles of Dwelling Regime (Prevailing Lifestyles)

- DR1 (29 sectors) : Places of urban lifestyles and diversity
- DR2 (13 sectors) : Places of village lifestyles, anchored to environmental amenities
- DR3 (18 sectors) : Places of automobile-dependent families
- DR4 (8 sectors) : Places of families critically accepting automobile-dependency
- DR5 (23 sectors) : Places of wealthy freely mobile households
- DR6 (8 sectors) : Places of families with intermediate behaviours
- DR7 (6 sectors) : Mixed places with internal dynamics and automobile dominance

5
 6 Figure 5 – A typology of dwelling regimes in the French Riviera metropolitan area.

7 **Profile DR1: Places of urban lifestyles and diversity**

8 It is the modal profile within the metropolitan area, covering 29 sectors. Populations living in these
 9 sectors are weakly motorised and have limited practice of car mobility. Conversely, most people walk
 10 (sometimes bike), both on working days and on weekends (car mobility is more important on week-
 11 ends). Owners and tenants balance each other, whereas seniors and people in their fifties living alone

1 are over-represented. Residents have modal habits which are typical of French city-centres and express
2 positive opinions on modal alternatives to the car, whereas negative opinions on cars and car use are
3 relatively widespread. Globally satisfied with the accessibility levels they enjoy, these urbanites don't
4 see the improvement of the transportation system as a priority. On the contrary, public security is a
5 main concern. On the whole, residents of DR1 sectors tend to be relatively unsatisfied with their
6 housing conditions, are more prone to move and make these sectors net generators of residential
7 mobility within metropolitan space. Nevertheless, these considerations don't hold for all DR1 sectors
8 and some sectors retain their inhabitants more than others. Geographically, this profile concerns the
9 central and the coastal sectors of Nice, Cannes and Antibes, as well as more peripheral coastal sectors.
10

11 **Profile DR2: Places of village lifestyles, anchored to environmental amenities**

12 This profile encompasses 13 sectors and is profoundly different from the former. The trip domination
13 indicator shows that these territories are relatively autonomous and never dominated by a single
14 metropolitan centre. They are the places of residence for many retirees. Inhabitants are not very
15 mobile, despite good motorisation levels. They are generally satisfied with their housing conditions
16 and living environment; low concerns about insecurity and environmental nuisances witness this
17 widespread satisfaction. In recent years many sectors have become increasingly attractive, confirmed
18 by the high ratio of newcomers and by the low residential emissivity ratio. Residential attractiveness is
19 higher in the middle hinterland and is the lowest in those upper hinterland sectors which do not
20 possess particular leisure amenities. Transportation and poor transit links are nevertheless main
21 concerns for households relying heavily on car mobility. The natural environment is essential for the
22 inhabitants, the desire for natural amenities being an important reason for moving to these sectors.
23 This is also reflected in the widespread practice of outdoor activities. Geographically the profile covers
24 homogeneously the upper alpine hinterland, the sectors of the Department of Var, and, more
25 surprisingly, the sector of Valbonne, home of the Sophia-Antipolis technology centre.

26 **Profile DR3: Places of automobile-dependent families**

27 This profile covers 18 sectors and describes a third distinctive dwelling regime in the French Riviera,
28 the one most closely associated with automobile dependency. Motorisation and modal behaviour
29 indicators have the highest mutual information with the belonging to the profile. DR3 sectors are
30 mainly inhabited by families with children, heavily car-dependent, hyper-mobile and hyper-motorised
31 (which is all the easier as they generally have private parking at home). Although a minority,
32 households of retirees or of people in their fifties living alone are not uncommon in some of the
33 sectors. Of course, car is the most used transportation mode both on working days and on weekends.
34 Mobility flows produced by inhabitants of these sectors create a web among places in the metropolitan
35 area, without being dominated by a single metropolitan centre, reflecting a highly poly-topic practice
36 of metropolitan space. Opinions reflect the predominance of this lifestyle based on high car mobility:
37 households have a positive opinion of the car, of the flexibility and ubiquity it allows, and are not
38 interested in alternatives to it. Geographically, DR3 sectors are situated in the western section of the
39 French Riviera, stretching from the seaside to the southern fringe of the middle hinterland.

40 **Profile DR4: Places of families critically accepting automobile-dependency**

41 This profile strongly resembles the previous one, but concerns only 8 sectors. It completes profile DR3
42 in identifying places mainly inhabited by families with children having car-dependent lifestyles. These
43 families live their car-dependent hyper-mobility in a more critical way. They are thus more concerned
44 by road safety. Even if they have negative attitudes towards alternatives to the car, many households
45 also advocate the improving of transit links. This reveals a potential for changing the modal habits
46 within these territories. Thus, at least on working days, people in DR4 sectors tend to walk and cycle
47 more than in profile DR3. Even more, positive opinions for the car are not always a majority. Finally,
48 observed hyper-mobility patterns are often due to constrained trips (journeys to work or school).
49 Residents are globally satisfied by suburban amenities at reach. Although they are still attractive for
50 new residents, profile DR4 sectors show weak values of replacement rate during the last 5 years.
51 Finally, residents are relatively polarised by a single metropolitan centre in their daily mobility, often

1 the city-centre of Nice or the new suburban downtown of the lower Var valley. From a geographical
2 point of view, profile DR4 faces and completes profile DR3: it concerns pericentral or peripheral
3 sectors in the middle hinterland in the eastern section of the French Riviera (above all in the hinterland
4 of Nice), with a few exceptions in the West.

5 **Profile DR5: Places of wealthy freely mobile households**

6 This profile groups 23 sectors whose resident populations are relatively mixed from a demographic
7 point of view but not socially (the upper classes are always overrepresented and there are almost no
8 social tenants). As far as modal habits are concerned, populations of profile DR5 sectors show average
9 behaviours: both hyper-motorisation and non-motorisation are around the average values of the
10 metropolitan area, car use on working days and on weekend has high probability of being important
11 but it is never the only transportation mode (as it often is in profiles DR3 and DR4) and walking and
12 cycling tend to be very important on weekends. Mobility levels are on the average but non-constraint
13 mobility (for leisure, commerce, service, etc.) is particularly high. Geographically, profile DR5 covers
14 coveted coastal and pericoastal sectors, including the capes and hilly areas north of Nice and Monaco.

15 **Profile DR6: Places of families with intermediate behaviours**

16 Once again, the profile is complementary to the previous one. It concerns a small number of sectors
17 (8) whose populations are averagely mobile. Unlike profile DR5, probabilities are higher for a more
18 important presence of families with children and for a much lesser presence of retirees. Even more
19 than profile DR5, car use and motorisation levels by these populations stick closer to the average
20 levels of the metropolitan area. Possession of transit season ticket is also on the average, and only
21 private parking space is more frequent than in the rest of the study area. Unlike profile DR5 (this
22 aspect is linked to the socio-demographic content of the profile), non-constraint mobility is less
23 important on working days and people tend to shop for food on weekends. Opinions on alternatives to
24 the car diverge within these sectors. Spatially, profile DR6 includes sectors in the East, namely in the
25 hinterland of Nice and Monaco, but also directly on the coast between Nice and Monaco.

26 **Profile DR7: Mixed places with internal dynamics and automobile dominance**

27 This profile is the least frequent in the study area, only concerning 6 sectors. Their populations are
28 relatively mixed (prevalence of families with children, followed by retirees) and show some diversity
29 in modal habits: the widespread use of car is combined with positive opinions on this transportation
30 mode; at the same time, the use of transit and walking is important on working days, car use becoming
31 more exclusive on weekends. Possession of transit season tickets is on the average. Residential
32 mobility is low, mainly within the sector and is not particularly dependent on the main metropolitan
33 centres. At the same time, on working days just like on weekends, residents are not attracted by any
34 single metropolitan centre. The majority of households are unsatisfied by their housing conditions.
35 Together with local residential movements, this could be explained in two different ways: location is a
36 priority more than intrinsic characteristics of the dwelling or, much more simply, strong constraints
37 (financial, logistical, etc.) play both on housing and location choice. For once, no clear geographic
38 cluster emerges, even if most of the sectors are in the western section of the metropolitan area and
39 include a few secondary urban centres (Grasse, Vence).

40
41 Despite missing values, sectors are assigned to profiles with extremely low uncertainty (around 0.01),
42 with a few exceptions. The city-centre of Cagnes-sur-mer is thus assigned to profile DR5 with
43 probability 0.75, with a residual probability of 0.25 of being assigned to profile DR1 (urban lifestyles).
44 This shows well the ambiguous classification of an increasingly residential city-centre having left
45 central activities migrate towards the seaside over the last decades.

46 On the whole, the regionalisation produced by this typology of dwelling regimes shows homogeneity
47 in the prevailing lifestyles of the most peripheral metropolitan sectors, namely the upper alpine
48 hinterland and the eastern section of the Department of Var. The seaside is marked both by urban
49 lifestyles and by wealthy freely mobile households. The middle hinterland and the pericoastal area are
50 finally segmented by different regimes. These are on average characterised by high (more or less
51 constrained) mobility levels and by prevalence of car mobility (sometimes in the form of car

dependency), more or less accepted and lived with. This segmentation, with a few exceptions, is marked by dividing lines following the main valleys, more or less perpendicular to the seaside.

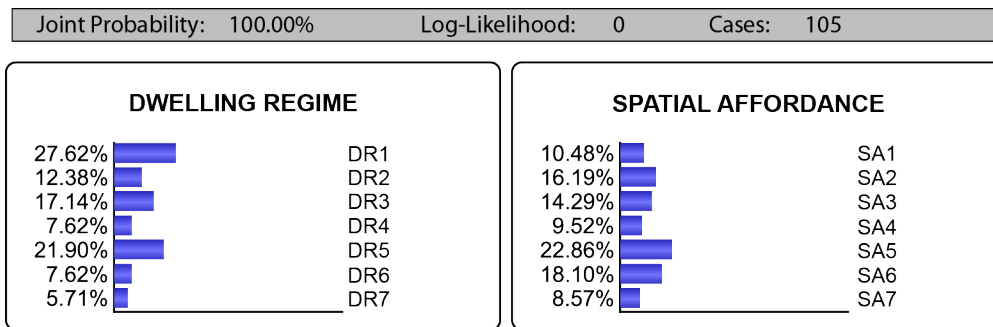


Figure 6: *A priori* probabilities for spatial affordance (SA2-SA5) and dwelling regimes (DR3-DR6).

7. Categories of place as combinations of Spatial Affordance and Lifestyles: an Empirical Cross-Analysis

The comparison of the two regionalisations shows sometimes strict correspondence, sometimes just partial overlapping or multiple correspondences between spatial affordance and dwelling regime of places. Nevertheless, not all combinations of spatial affordances and prevailing lifestyles are possible. It is thus interesting to use BN to explore probabilities of association among profiles. Correspondences, even when they are complete, cannot be explained through simple cause-to-effect relations (a given spatial affordance producing the prevailing lifestyle of residents), as territorial phenomena are much more complex. Spatial affordance factors and lifestyles set in over several decades. Once a lifestyle has spread to become a dwelling regime within a place, it can contribute to shape its spatial affordance: building types, housing offer, road and transit links are also the fruit of planning decisions or market behaviours responding to established lifestyles. Furthermore, as the same spatial affordance can correspond to different dwelling regimes, we have to dismiss any determinism of spatial affordance, a possibilistic approach being much more appropriate. Indeed, we will look for categories of places by identifying consistent associations between spatial affordances and dwelling regimes. Statistical consistency will be used as an indicator of “congruence”, following Offner (1993) on the relationship between transportation and territorial development: no simple cause-to-effect but complementarity between phenomena observed in a more complex system behaviour.

Once again, BN offer an interesting modelling opportunity. The starting point is the *a priori* probabilities of the different profiles of place within the study area (Figure 6), which will serve as reference point in the cross-analysis.

The first question underlying our analysis is to reveal the dwelling modes which are most probably associated with every kind of spatial affordance. Answering this question means identifying empirically the ability of spatial affordance to be “congruent” with a subset of prevailing lifestyles of the resident population. BN can answer this question with *a posteriori* probability distributions whenever the spatial affordance class is entered as evidence (Figure 7). The second question, mirroring the previous one, is to identify the spatial affordance compatible with a given dwelling regime. We can thus understand the residential attraction exerted by places with different spatial affordance for households attached to a particular lifestyle. Once again, the BN model supplies *a posteriori* probability distributions whenever the dwelling regime is entered as evidence (Figure 8).

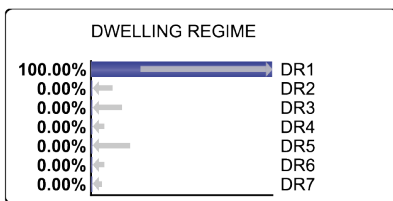
The cross-analysis of spatial affordance and lifestyles within the metropolitan area of the French Riviera comes to the following main results:

- First of all, spatial affordance of places with higher density, centrality, functional and social diversity seem to have a real ability to catalyse urban lifestyles within the resident population, showing reduced hyper-mobility and hyper-motorisation and favouring modal alternatives to the car. Profile DR1 corresponds thus with high probability to spatial affordances SA2 and SA1 and only to a lesser degree SA3. The association is perfect between SA1 and DR1. SA2 is also strongly associated with urban lifestyles, but can also be the habitat of less diverse populations (wealthy

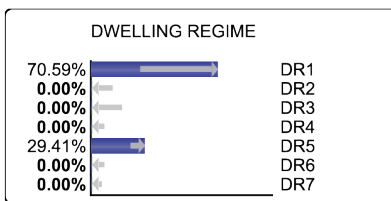
freely mobile households of profile DR5). Profile SA3 is compatible with urban dwelling regime DR1, but the latter is neither the only nor the most probable regime associated with it. Some factors of dissatisfaction over quality of life in the city (security, housing conditions) can nevertheless push households with urban lifestyles to move to places which are less compatible with them.

- Secondly, a link exists between car dependent lifestyles and residential suburban fabric. On the one hand, the most car-dependent dwelling regime (DR3) has high probability (over 0.6) of finding its ideal habitat in places with spatial affordance profile SA5, with the second most probable habitat being residential suburban fabric in the middle hinterland (SA6). Car-dependency is thus experienced in a relatively positive way in places closer to the seaside and the highway network, producing high accessibility levels. It starts to be challenged (dwelling regime DR4) in places of the middle hinterland that do not enjoy high accessibility levels (spatial affordance SA6 with probability 0.75). This could incline part of the resident population within these sectors to accept changes in the spatial affordance (namely in terms of urban morphology and transportation links) making space less prone to car dependence. It should be remarked that highly accessible residential suburban fabrics close to the seaside (profile SA5) are compatible with a wide variety of dwelling regimes. If car-dependent DR3 lifestyles are the most probable (0.45), all other dwelling modes (with the exception of urban lifestyles DR1) can become predominant in these places, and more particularly the dwelling mode of the freely mobile wealthy households (DR5).

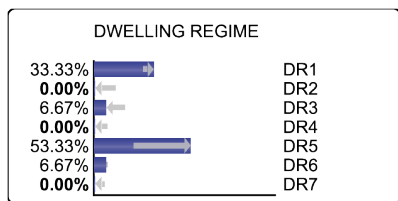
Joint Probability: 10.4761905%
 Log-Likelihood: 3.254813899
 Cases: 11
 Evidence: Spatial Affordance = SA1



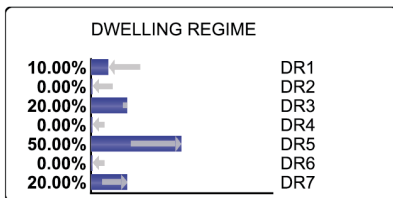
Joint Probability: 16.1904762%
 Log-Likelihood: 2.626782676
 Cases: 17
 Evidence: Spatial Affordance = SA2



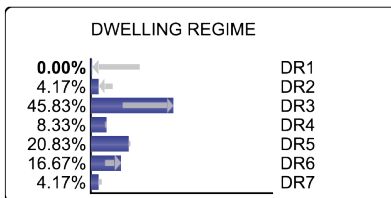
Joint Probability: 14.2857143%
 Log-Likelihood: 2.807354922
 Cases: 15
 Evidence: Spatial Affordance = SA3



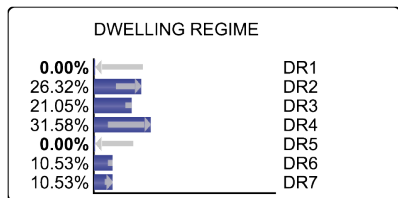
Joint Probability: 9.5238095%
 Log-Likelihood: 3.392317423
 Cases: 10
 Evidence: Spatial Affordance = SA4



Joint Probability: 22.8571429%
 Log-Likelihood: 2.129283017
 Cases: 24
 Evidence: Spatial Affordance = SA5



Joint Probability: 18.0952381%
 Log-Likelihood: 2.466318004
 Cases: 19
 Evidence: Spatial Affordance = SA6



Joint Probability: 8.5714286%
 Log-Likelihood: 3.544320516
 Cases: 9
 Evidence: Spatial Affordance = SA7

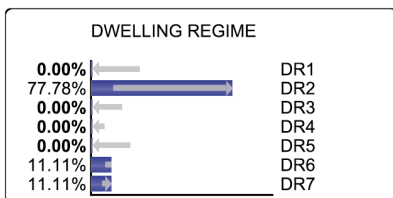


Figure 7: Probabilistic correspondence of prevailing lifestyles with a given class of spatial affordance.

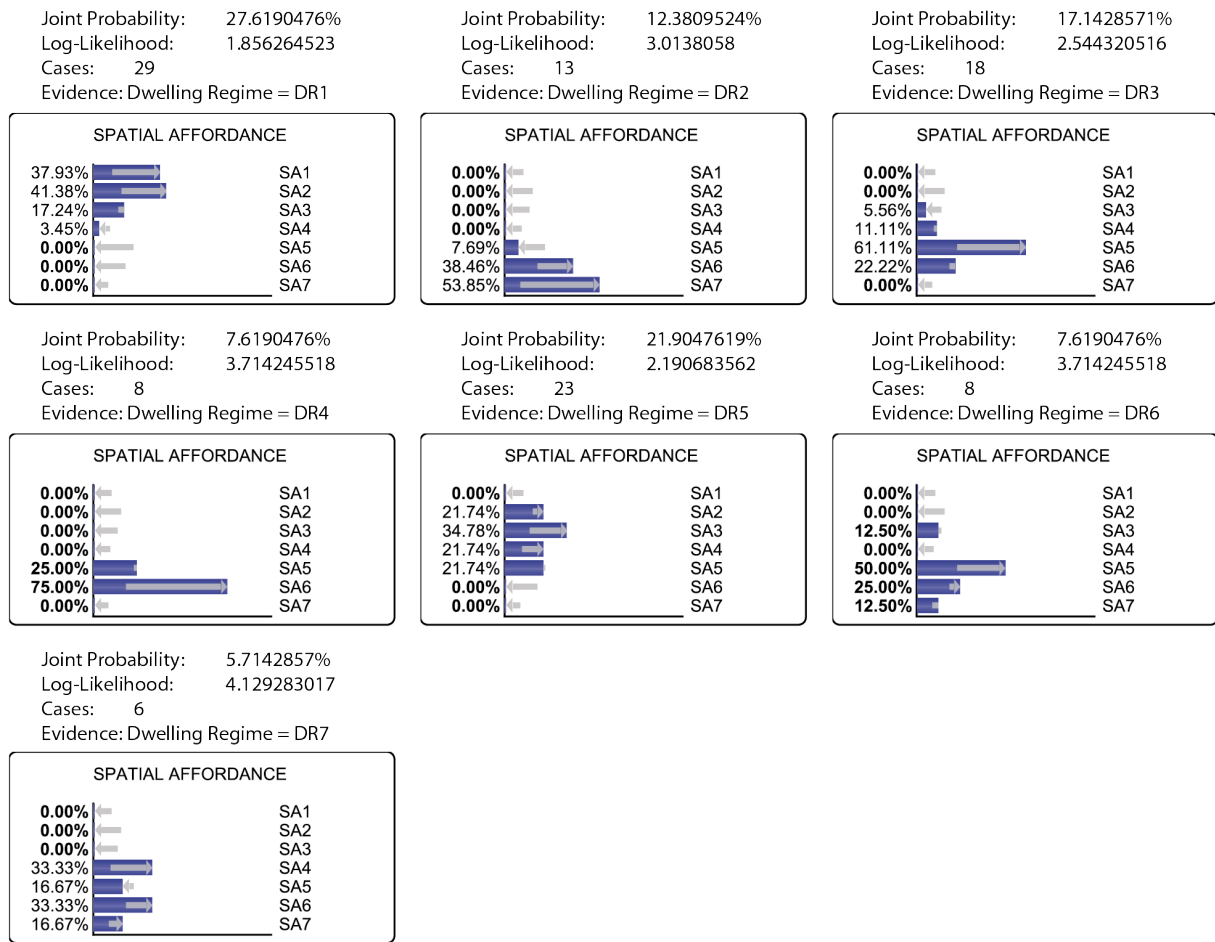
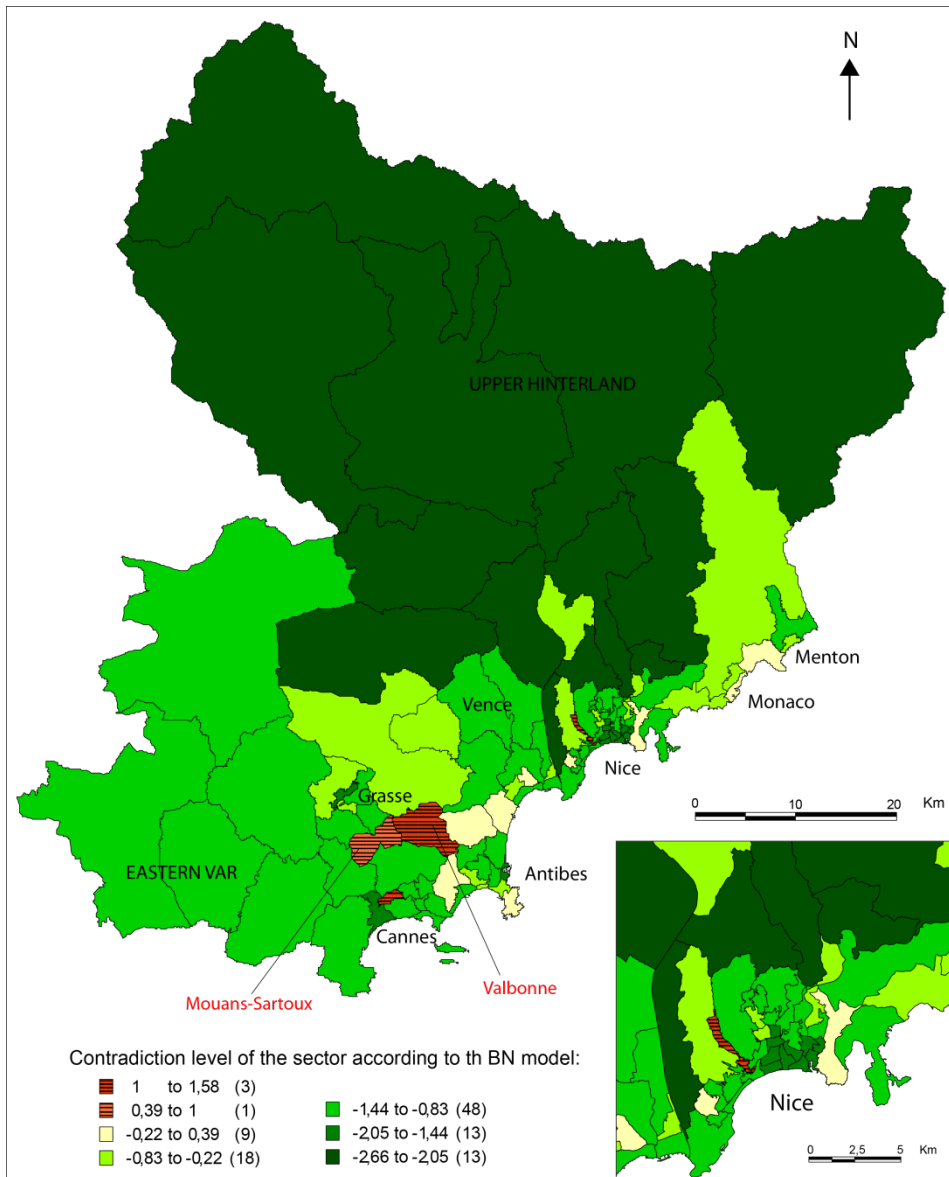


Figure 8: Probabilistic correspondence of spatial affordance with a given class of prevailing lifestyle.

- Thirdly, village lifestyles (DR2) find their ideal habitat in sectors of the middle and upper hinterland (spatial affordance profiles SA6 and SA7). Within these sectors two different fabrics combine: old villages (predominant in SA7) and residential subdivisions (predominant in SA6). What unites these two profiles is the presence of highly appreciated environmental amenities, which is a priority for DR2 lifestyles, but also low accessibility levels by car and transit. Exceptionally, village lifestyles are possible in residential suburban sectors closer to the seaside. The dwelling regime DR2 concerns here more affluent populations (metropolitan-rural), like in Valbonne. The Eastern Var sectors have spatial affordance of residential suburban fabric with relatively good car accessibility but are the habitat for normally more peripheral village lifestyles. Looking for the dwelling regimes most probably associated with spatial affordance types SA7 and SA6, we find that SA7 is almost always associated with village lifestyles (except for the coastal sectors, linked to more mobile DR7 and DR6 regimes). This is not true for residential suburban fabric in the middle hinterland (SA6), which is compatible with a diversity of lifestyles, but urban lifestyles (DR1). This diversity shows that strong car dependency (DR3, DR4) is not the only possible regime in the middle hinterland of the Riviera.
- Finally, one of the main peculiarities of the Riviera is the existence of places with a preponderance of wealthy freely mobile populations (profile DR5). Spatial affordance types compatible with this lifestyle are diverse (SA3, SA2, SA4 and SA5) but have a few common properties. The first three are relatively dense and close to metropolitan centres, enjoying very good accessibility for car, transit and walking. Increasing social diversity to take in households more prone to the use of transit, walking or cycling (students, lower income households) could make these places less dependent on car mobility. When associated with DR5 dwelling modes, pericoastal suburban fabrics (SA5) are highly coveted seaside sectors with expensive individual housing. By reverting our analysis, spatial affordance of types SA3 and SA4 are compatible with different dwelling regimes. The former is associated with wealthy freely mobile populations (DR5 with probability

1 0.53) as well as with urban lifestyles (DR1 with probability 0.33). The latter can be the habitat for
 2 freely mobile populations (DR5 with probability 0.50), for mixed populations with internal
 3 dynamics and automobile dominance (DR7 with probability 0.20) and with car-dependent families
 4 (DR3 with probability 0.20).
 5



6
 7 Figure 9: Contradiction analysis in the study area.
 8

9 Associations between spatial affordance and dwelling regime profiles are the result of statistical
 10 regularities that hold within the study area and are reflected in the probability tables of the BN model.
 11 It is possible to evaluate the overall relation between the two variables. Their symmetric normalized
 12 mutual information is thus 41.84% (meaning that every variable already includes more than 40% of
 13 the information content of the other one). By focusing only on the most probable associations between
 14 the stochastic variables, the predictive power of the probabilistic model is even higher than this value:
 15 dwelling regime can be predicted with 57.14% accuracy from spatial affordance, whereas the latter
 16 can be predicted with 47.62% accuracy from dwelling regime, and this without any particular
 17 hypothesis of cause-to-effect relation between the variables.

18 Geographers are often interested both in models and in deviations from models. It is thus possible,
 19 thanks to the probabilistic approach, to analyse the contradiction level between the BN model and
 20 every sector of the metropolitan space (Figure 9). Contradiction level is the base-2 logarithm of the
 21 ratio between the product of independent probabilities for the observed spatial affordance and dwelling

1 regime profiles for a given sector (no link is supposed to exist between them) and the joint probability
2 expressed by the BN model (where the probabilistic link is assumed). The value is usually negative, as
3 the BN model encodes statistical dependencies that have higher likelihood than the unconnected
4 model. The lower the value, the better the BN describes the relationship between spatial affordance
5 and dwelling regime in the sector. This is for example the case for much of the upper hinterland, for
6 the middle hinterland north of Nice and for the central neighbourhoods in Nice.
7 A few sectors are nevertheless exceptions to the statistical regularities encoded in the BN model. They
8 are hatched in Figure 9 and have positive contradiction levels. In the western section of the Riviera,
9 the sectors of Valbonne and Mouans-Sartoux are good examples of such exceptions. They have both
10 spatial affordance of type SA5 (pericoastal suburban fabric with high road accessibility), which is
11 typically associated with dwelling modes DR3 or DR5. On the contrary, they show specific patterns of
12 village lifestyles DR7 (Valbonne) and of mixed-population places with internal dynamics and
13 automobile dominance DR2 (Mouans-Sartoux). The BN model can thus indicate both archetypical
14 associations between spatial affordance and lifestyles, which define the most representative categories
15 of place in the study area, and cases where the probabilistic relationships are challenged, suggesting
16 local specificities that characterise different patterns of place.

17 **8. Conclusions**

18 Overall, our applications show how it is possible to generalise categories of places (on the basis of
19 profiles of spatial affordance and of dwelling regimes and of some probabilistic relationships between
20 the two). The three BN models provide the generalisations we were looking for, but do allow
21 exceptions, hinting at the existence of a few unique instances of places, whose peculiarities are
22 nevertheless identified and categorized. More generally, BN segmentation allows the search of
23 archetypes of place within an appropriate spatial database. BN can thus be employed to develop a mix
24 of theory-driven and data-driven modelling methodology that echoes the heuristics of the search of
25 ideal types first proposed by Max Weber (1914). The probabilistic framework of BN proves
26 particularly well suited to capture the fuzzy relationship existing between spatial affordance and
27 lifestyles. The data-mining applications were relatively robust and were able to produce elements of
28 knowledge from incomplete databases and imperfect indicators. They were also able to assess the
29 uncertainty of the results.

30 A few limits in the proposed methodology have to be highlighted. The main weakness of the
31 application is the limited number of case studies (the 105 sectors of the Household Mobility Survey in
32 the French Riviera), which sometimes resulted in over fitting and/or in the creation of profiles of
33 places with intermediate characteristics, very few sectors and dubious generalization aptitude. A
34 second weakness concerns the quality of the indicators used. Noisy values for some indicators are
35 mainly the result of the uneven definition of spatial units: sectors in the coastal cities are much smaller
36 and are fairly well described by our indicators, whereas sectors in the hinterland are generally much
37 bigger and are characterised by wider inner diversity both in terms of spatial affordance and of
38 dwelling modes. Spatial unit definition was unfortunately imposed by the main source of data (the
39 household mobility survey) and could not be modified without losing statistical reliability.

40 Of course, the data-driven application does not follow a purely inductive data mining approach:
41 concepts were created with a background of theoretical assumptions and indicators for these concepts
42 were later sought for. Indeed, the conceptualisation behind indicators selection and measurement
43 contributes to the robustness of the analysis. As far as the concepts are concerned, the research
44 confirms the need to enlarge the view of the built-up form / mobility relationship. More particularly, it
45 shows the usefulness of the concepts of spatial affordance and of dwelling regime (prevailing
46 lifestyles). Both terms of the analysis (spatial affordance, on the one side, and dwelling regime, on the
47 other) emerge as systemic characteristics of places. The different aspects of built-up form overlap
48 among them as well as with other functional and perceived characteristics of the urban space,
49 contributing to a more general “habitat” or “ecosystem” for urban and metropolitan life, well captured
50 by the concept of spatial affordance, to which we gave a first operationalization. At the same time,
51 mobility behaviours were placed within the broader context of lifestyles of metropolitan populations,
52 reflecting their habits, attitudes, values and aspirations in the metropolitan space. Finally, place itself,

1 characterised both by spatial affordance and dwelling regime, was always considered as an elementary
2 cell within the relational space of the metropolitan area. On the bases of these concepts and of the BN
3 methodology, we produced a better understanding of the spatial segmentation of the metropolitan area
4 of the French Riviera. Several issues usually raised within urban sustainability policies (like car
5 dependency, urban sprawl, hyper-mobility vs. lack of mobility, etc.) appear as facets of more complex
6 relationships between spatial affordance and lifestyles and impact differently the sectors of the
7 metropolitan area. These relationships cannot be reduced to simple cause-to-effect and policies aiming
8 at curbing or fostering particular phenomena (be it car dependency or urban densification) should take
9 into account these complex relationships shaping places.

10 Further developments of the proposed methodology could open new perspectives for planners wishing
11 to understand and to solve crucial issues of urban sustainability in a metropolitan context. First of all,
12 further empirical studies following the proposed protocol of analysis will be welcome in order to
13 generalise the results we found on the French Riviera: it could then be possible to identify even more
14 consistent connexions between spatial affordance and dwelling regimes in metropolitan contexts.

15 Social morphology issues could be better integrated in the analysis, enriching both the characterisation
16 of spatial affordance (housing, availability of service, quality of public space, planning policies, etc.)
17 and dwelling modes. Other essential sustainability issues of metropolitan development could then be
18 addressed, namely residential segregation (selective gentrification and pauperisation of places within
19 the metropolitan area), with the associated impacts on mobility behaviours and dwelling regimes.

20 Description of spatial affordance of places should also be enriched by ad-hoc surveys, exploring the
21 cognition of metropolitan space and of its characteristics by its inhabitants. Perceived and objectively
22 measured spatial characteristics could then be cross-analysed. This is a direction of research already
23 exploited by sociologists of transportation (Kaufmann 2000) using more qualitative protocols than our
24 Bayesian approach.

25 In a different perspective, typologies could be produced for “trajectories” of places, following their
26 evolution over time in terms of spatial affordance and dwelling regime. By reconstructing trajectories
27 of places within a given metropolitan area over several decades, we could improve our understanding
28 of the role of the metropolisation process on observed patterns of change. This could also open the
29 way to metropolitan strategic foresight and scenario building in the light of the probabilistic relations
30 describing the trajectory of places within the metropolitan area.

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1 **Appendix A – The 27 Indicators of Spatial Affordance**

2 **Geographic Situation within the Metropolitan Area**

- 3 1. SITUATION: Situation with respect to the seaside (coastal, pericoastal, middle hinterland, upper hinterland)
- 4 2. CENTRALITY: Visiting ratio during working days (incoming trips / resident population, homebound trips
- 5 are excluded)
- 6 3. WEEKEND CENTRALITY: Visiting ratio during weekends (incoming trips for leisure activities and
- 7 shopping / resident population)

8 **Morphology of the Built-Up Fabric**

- 9 4. LAND COVERAGE: Land coverage ratio within the built-up area
- 10 5. FUNCTIONAL DENSITY: Functional density ratio (jobs + education places + resident population / built up
- 11 area)
- 12 6. BUILT-UP DENSITY: Building floorage density within the built-up area
- 13 7. TYPICAL SPACING: Typical spacing between built-up elements (A = 5-20 m, B = 28-113 m, C = 160-1280
- 14 m, the two most significant values are considered resulting in spacing typologies like AA, AB, BC, etc.)

15 **Morphology of the Street Network**

- 16 8. VASCULARISATION: Vascularisation of the built-up area by the street network (lengths of street segments
- 17 / built-up area)
- 18 9. DEAD ENDS: Share of degree 1 nodes in the street network
- 19 10. CROSSROADS: Share of nodes with degree 4 or more in the street network
- 20 11. LOCAL REACH: Local accessibility to built-up elements (nb of built-up elements within 2 km on the street
- 21 network)
- 22 12. STRAIGHTNESS: Normalised straightness of the street network within a 2 km radius (average ratio between
- 23 Euclidean distance and network distance when connecting all buildings closer than 2 km)

24 **Socioeconomic Morphology**

- 25 13. SOCIAL MIX: Social diversity measured on the housing occupation status (relative entropy index compared
- 26 to average distribution in the study area)
- 27 14. FUNCTIONAL MIX: Functional diversity (relative entropy index compared to average distribution in the
- 28 study area)
- 29 15. RETAIL RESIDENTIAL MIX: Balance between retail and residential functions (retail surface / 1000
- 30 inhabitants)

31 **Accessibility**

- 32 16. ROAD ACCESSIBILITY JOBS: Road accessibility to jobs and education places (< 30 minutes on the road
- 33 network)
- 34 17. TRANSIT+WALK ACCESSIBILITY JOBS: Transit + Walking accessibility to jobs and education places (<
- 35 30 min on the transit network + walking)
- 36 18. ROAD ACCESSIBILITY RETAIL: Road accessibility to retail activity (retail surface < 30 minutes on the
- 37 road network)
- 38 19. RANSIT+WALK ACCESSIBILITY RETAIL: Transit + Walking accessibility to retail activity (retail
- 39 surface < 30 minutes on the transit network + walking)

40 **Housing**

- 41 20. INDIVIDUAL HOUSING: Share of individual housing in the housing stock
- 42 21. FLATS IN BUILDINGS: Share of flats in high- to medium-rise buildings (more than 3 floors) in the housing
- 43 stock
- 44 22. SMALL FLATS: Share of one- and two-room apartments in the housing stock
- 45 23. BIG DWELLINGS: Share of dwelling with at least 4 main rooms in the housing stock
- 46 24. RENTAL HOUSING STOCK: Share of dwelling for rental (both social housing and private sector) in the
- 47 housing stock
- 48 25. OLD DWELLINGS: Share of dwelling built before 1949 in the housing stock
- 49 26. POST-WAR DWELLINGS: Share of dwelling built between 1949 and 1974 in the housing stock
- 50 27. 80s-90s DWELLINGS: hare of dwelling built between 1982 and 1990 in the housing stock

51 **Appendix B – The 46 Indicators of Dwelling Regime**

52 **Socio-demographic Characteristics of Households**

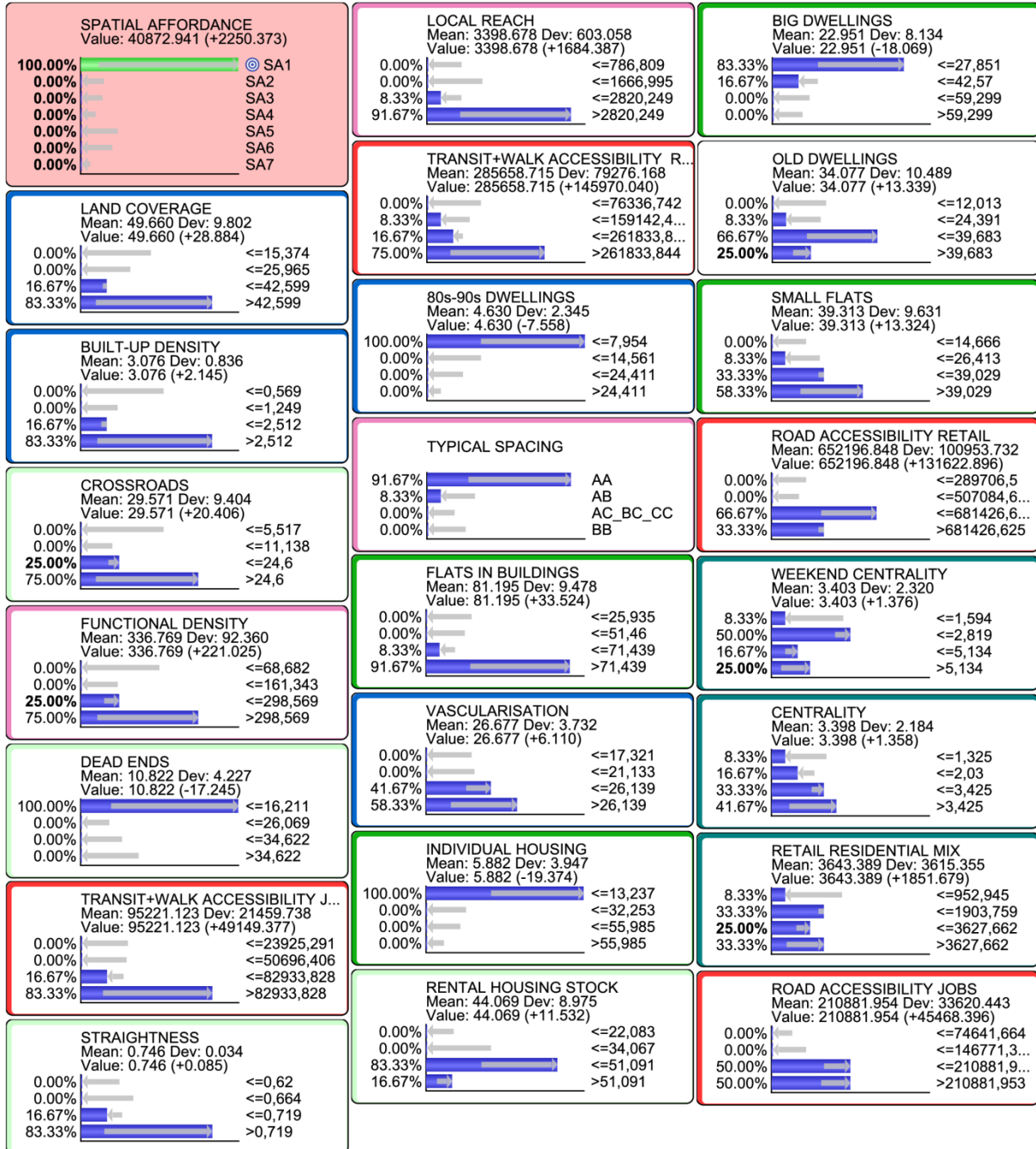
- 53 1. COUPLES CHILDREN: Share of couples with children within the resident households
- 54 2. SINGLES >50: Share of singles aged 50 or more within the resident households
- 55 3. EXECUTIVES: Share of executives and professionals within the resident population aged 6 or more
- 56 4. WORKERS EMPL: Share of workers and employees within the resident population aged 6 or more

- 1 5. RETIREES: Share of retirees within the resident population aged 6 or more
- 2 6. OWNERS: Share of households owning their main home
- 3 7. SOCIAL TENANTS: Share of households living in subsidized social housing (HLM tenants)
- 4 **Daily Mobility Habits of Households**
- 5 8. METRO DOMINATION WD: Share of trips towards the dominant metropolitan centre on working days
- 6 9. INTERNAL WD: Share of internal trips on working days
- 7 10. IMMOBILITY: Share of resident population not leaving their dwelling on working days
- 8 11. HYPER-MOBILITY: Share of hyper-mobile residents (more than 4 trips / day) on working days
- 9 12. SOFT MOBILITY: Share of soft mobility (pedestrian or bicycle trips) to and from the survey sector
- 10 13. CAR MOBILITY: Share of car or motorbike trips to and from the survey sector
- 11 14. NON-SYSTEMATIC MOB: Share of non-systematic trips (motives commerce, service, leisure, etc.) by the
- 12 resident population
- 13 **Weekend Mobility Habits of Households**
- 14 15. FOOD WE: Share of resident population shopping for food on weekends
- 15 16. HOME LEISURE: Share of home leisure activities among weekend leisure activities
- 16 17. OPEN-AIR LEISURE: Share of environmental / open-air leisure activities among weekend leisure activities
- 17 18. METRO DOMINATION WE: Share of trips towards the dominant metropolitan centre on weekends
- 18 19. INTERNAL WE: Share of internal trips on weekends
- 19 20. SOFT MOBILITY WE: Share of pedestrian or bicycle trips to and from the survey sector on weekends
- 20 21. CAR MOBILITY WE: Share of car or motorbike trips to and from the survey sector on weekends
- 21 **Residential Mobility and Motivations**
- 22 22. RESIDENTIAL ROOTING: Share of households living in the sector from before 1988
- 23 23. RESIDENTIAL TURNOVER: Share of newcomers (households having moved in the sector after 2005)
- 24 24. FINANCIAL CONST MOVING IN: Share of households mentioning financial constraint among the reasons
- 25 for having moved in the sector
- 26 25. BIGGER DWELL MOVING IN: Share of households mentioning the need of a bigger dwelling among the
- 27 reasons for having moved in the sector
- 28 26. SUBURB AMENIT MOVING IN: Share of households mentioning the desire of suburban and exurban
- 29 amenities among the reasons for having moved in the sector
- 30 27. SUBURB AMENIT DISSATISFACTION: Share of households mentioning the lack of suburban and
- 31 exurban amenities as housing dissatisfaction factor in the sector
- 32 28. DWELL QUAL DISSATISFACTION: Share of households mentioning poor dwelling quality as housing
- 33 dissatisfaction factor in the sector
- 34 29. HOUSING SATISFACTION: Share of households satisfied with their housing conditions in the sector
- 35 30. INTERNAL RES MOVES: Share of residential inflows from households already living in the sector
- 36 31. RES MOVES N-C-A: Share of residential inflows from households previously living in Nice, Antibes or
- 37 Cannes
- 38 32. RES MOVES OUT OF METRO: Share of residential inflows from households previously living outside the
- 39 metropolitan area
- 40 33. RESIDENTIAL EMISSIVITY: Residential emissivity ratio (population moving out of the sector between
- 41 2003 and 2008 / resident population in 2008)
- 42 **Household Equipment for Transportation**
- 43 34. NON MOTORISED: Share of non-motorised households (households having no motor vehicle)
- 44 35. HYPER-MOTORISED: Share of hyper-motorised households (households having at least one motor vehicle
- 45 per person aged more than 14)
- 46 36. PRIVATE PARKING: Share of motor-vehicles enjoying private parking space / garage at night
- 47 37. SEASON TICKET: Share of population aged 5 or more having transit season ticket and no driver licence
- 48 38. NO S TICKET NO LICENCE: Share of population aged 5 or more having neither transit season ticket and
- 49 nor driver licence
- 50 **Opinions on Local Life and Mobility**
- 51 39. POSITIVE OPINION CAR: Share of resident population having positive opinions on the car
- 52 40. POSITIVE OPINION CAR ALTERN: Share of resident population having positive opinions on alternatives
- 53 to the car (transit, walking, cycling)
- 54 41. SECURITY PRIORITY: Share of resident population thinking that public security is a priority for improving
- 55 quality of life
- 56 42. TRANSPORT PRIORITY: Share of resident population thinking that transportation is a priority for
- 57 improving quality of life
- 58 43. EMPLOYEMENT PRIORITY: Share of resident population thinking that employment is a priority for
- 59 improving quality of life

- 1 44. ROAD SAFETY PRIORITY: Share of resident population thinking that road safety is a priority for
- 2 improving mobility of people
- 3 45. TRANSIT PRIORITY: Share of resident population thinking that transit is a priority for improving mobility
- 4 of people
- 5 46. POLLUTION PRIORITY: Share of resident population thinking that noise and pollution are a priority for
- 6 improving mobility of people

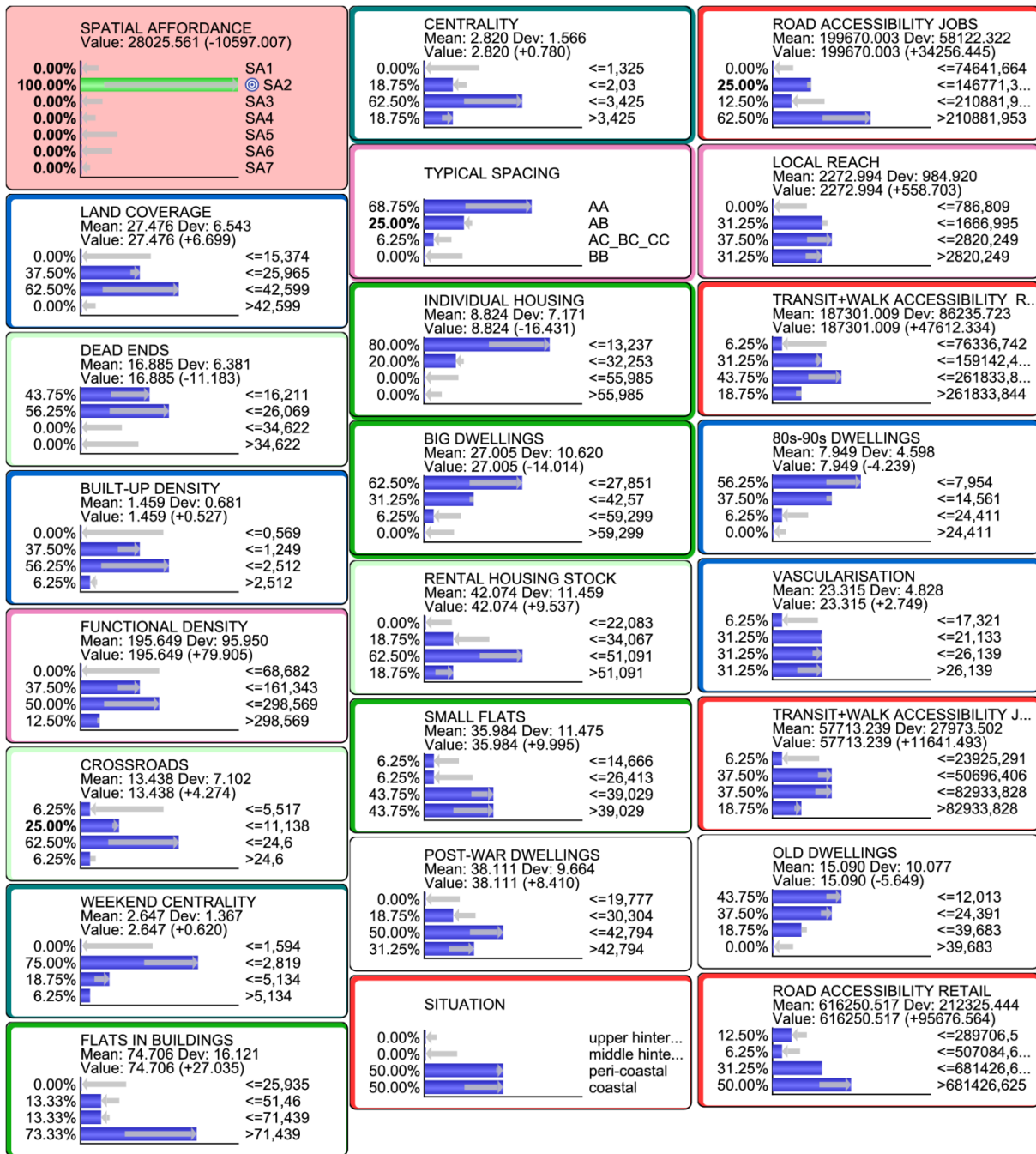
7 Appendix C – The Probability Profiles of Spatial Affordance Clusters

8 Reading key: variables are listed in descending order of mutual information with the considered cluster. Only the
 9 most important 23 variables are shown. Colours regroup variables according to underlying synthetic factor.



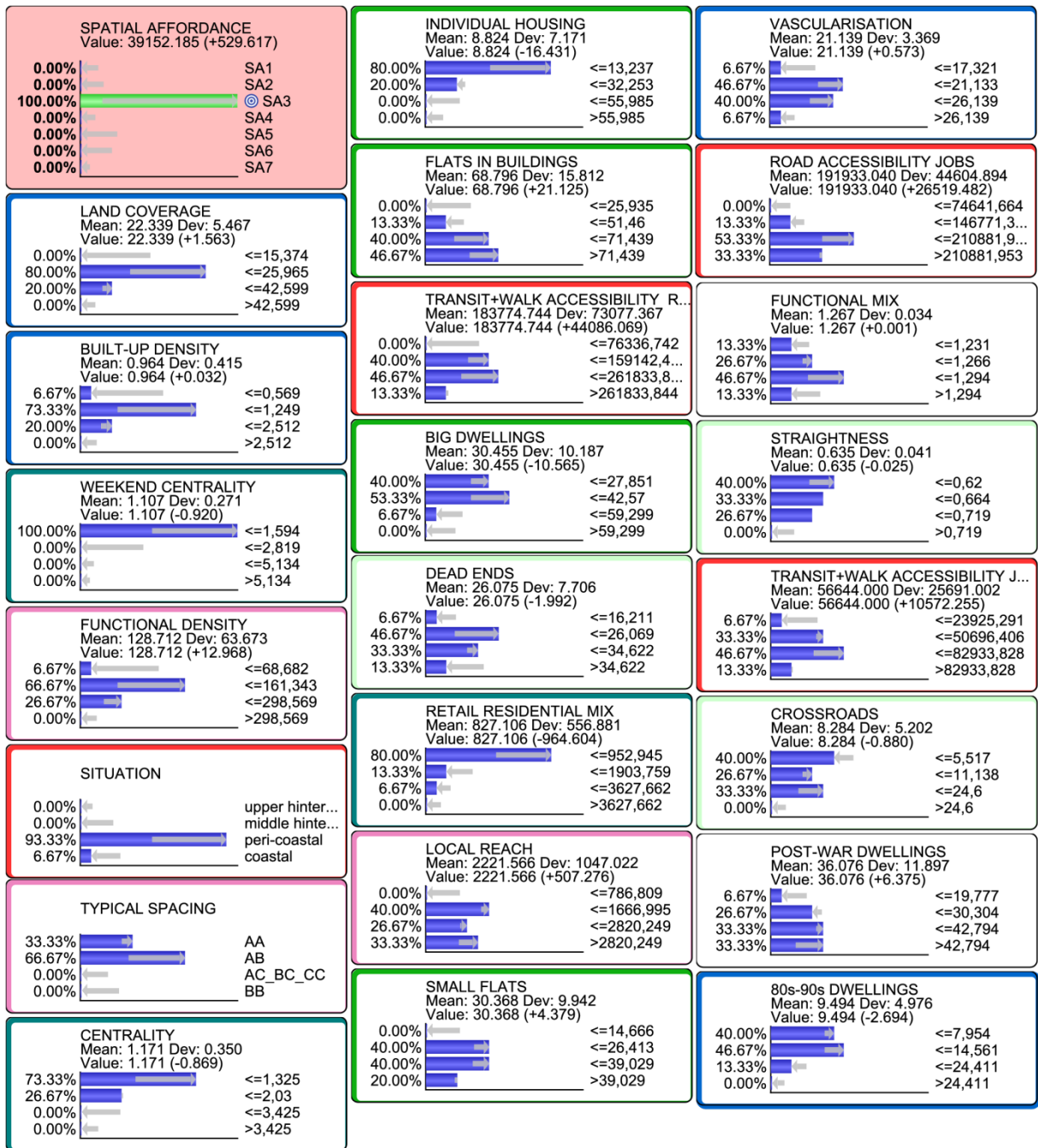
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Figure C1 – Probabilistic profile of cluster SA1 - Planned urban cores with meshed, dense and old urban fabric.

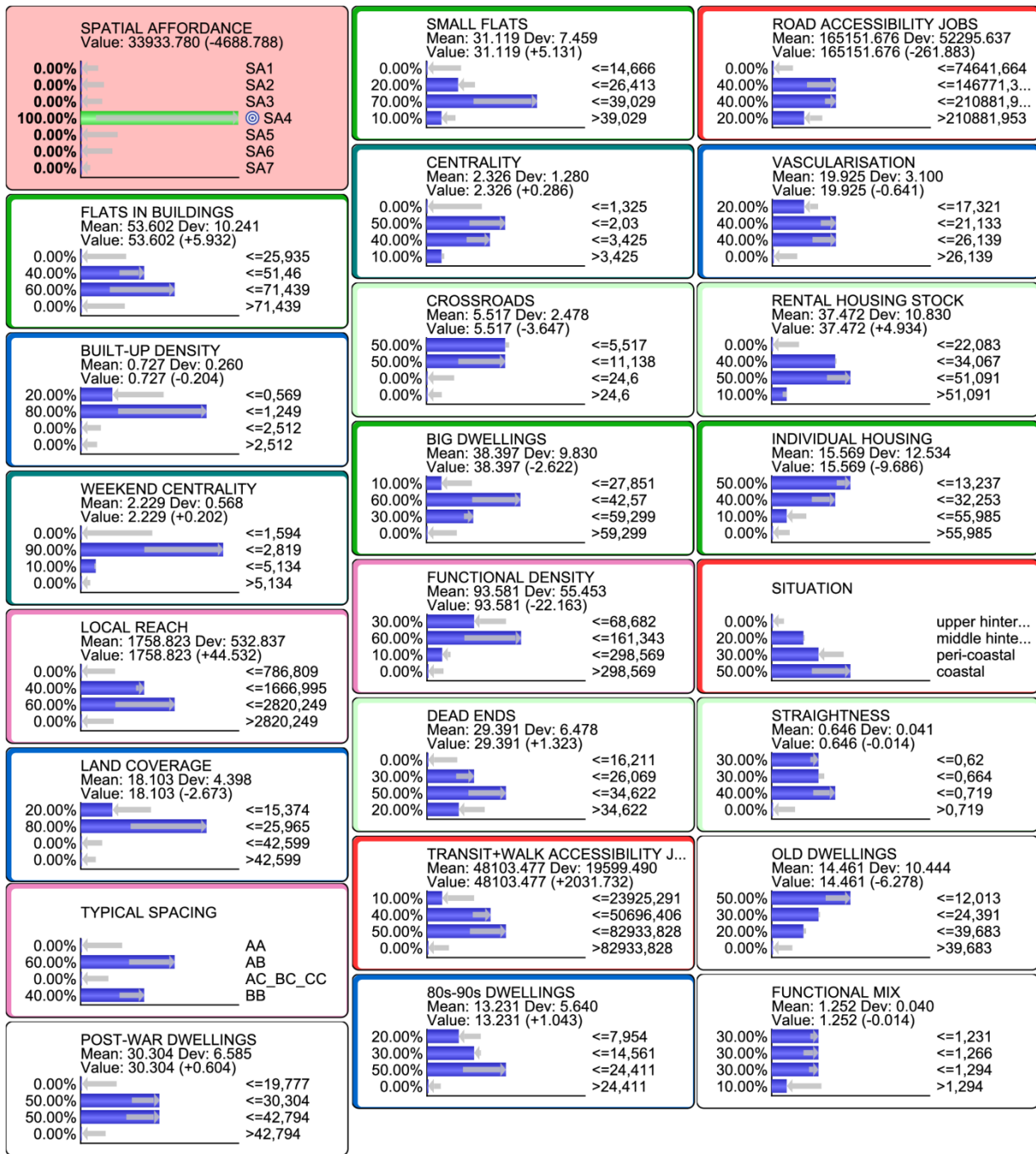


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Figure C2 – Probabilistic profile of cluster SA2 - Centres and pericentral extensions with dense but irregular urban fabric.

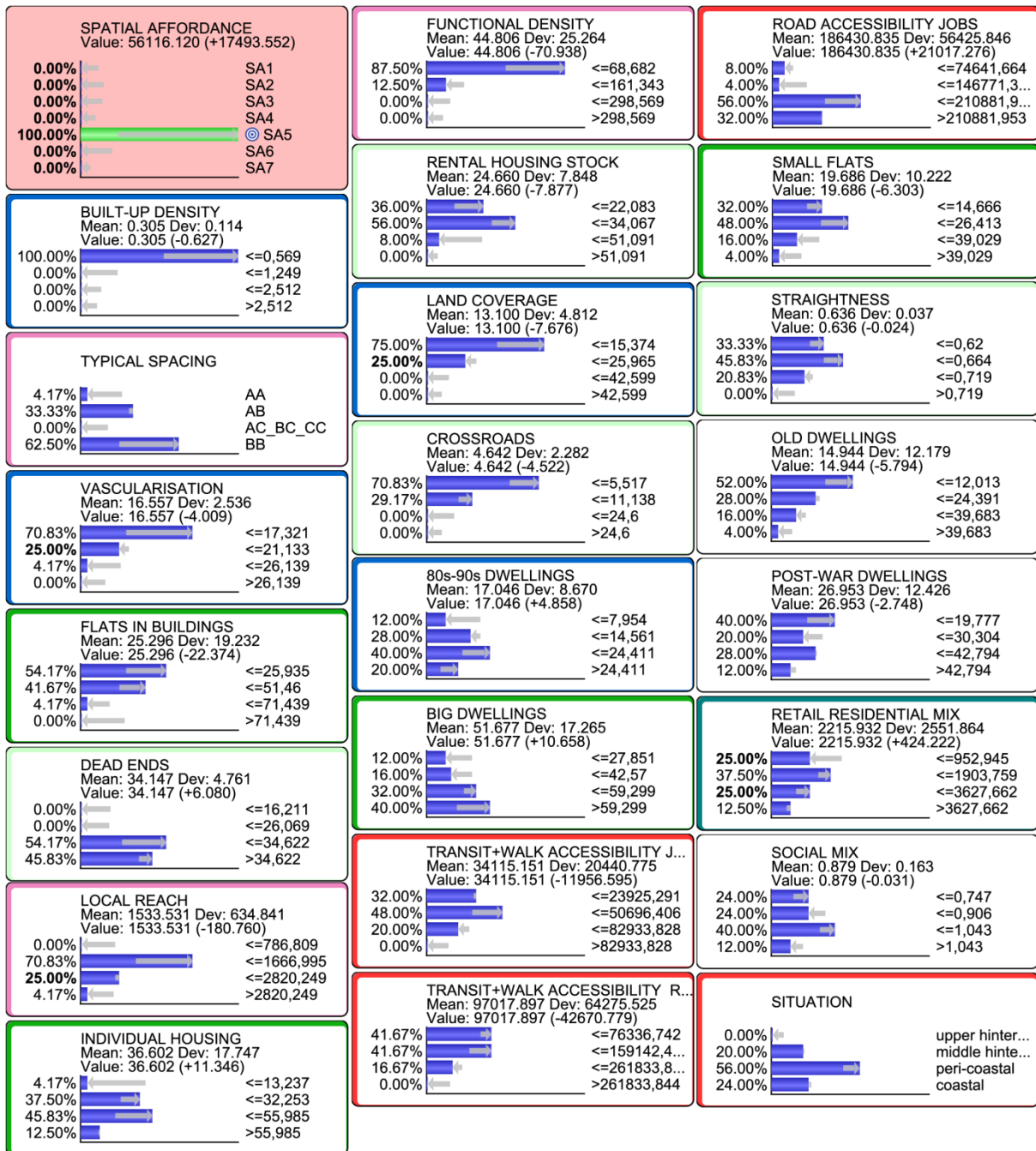


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 2 Figure C3 – Probabilistic profile of cluster SA3 - Peripheral, mainly residential, irregular urban fabric.
 3

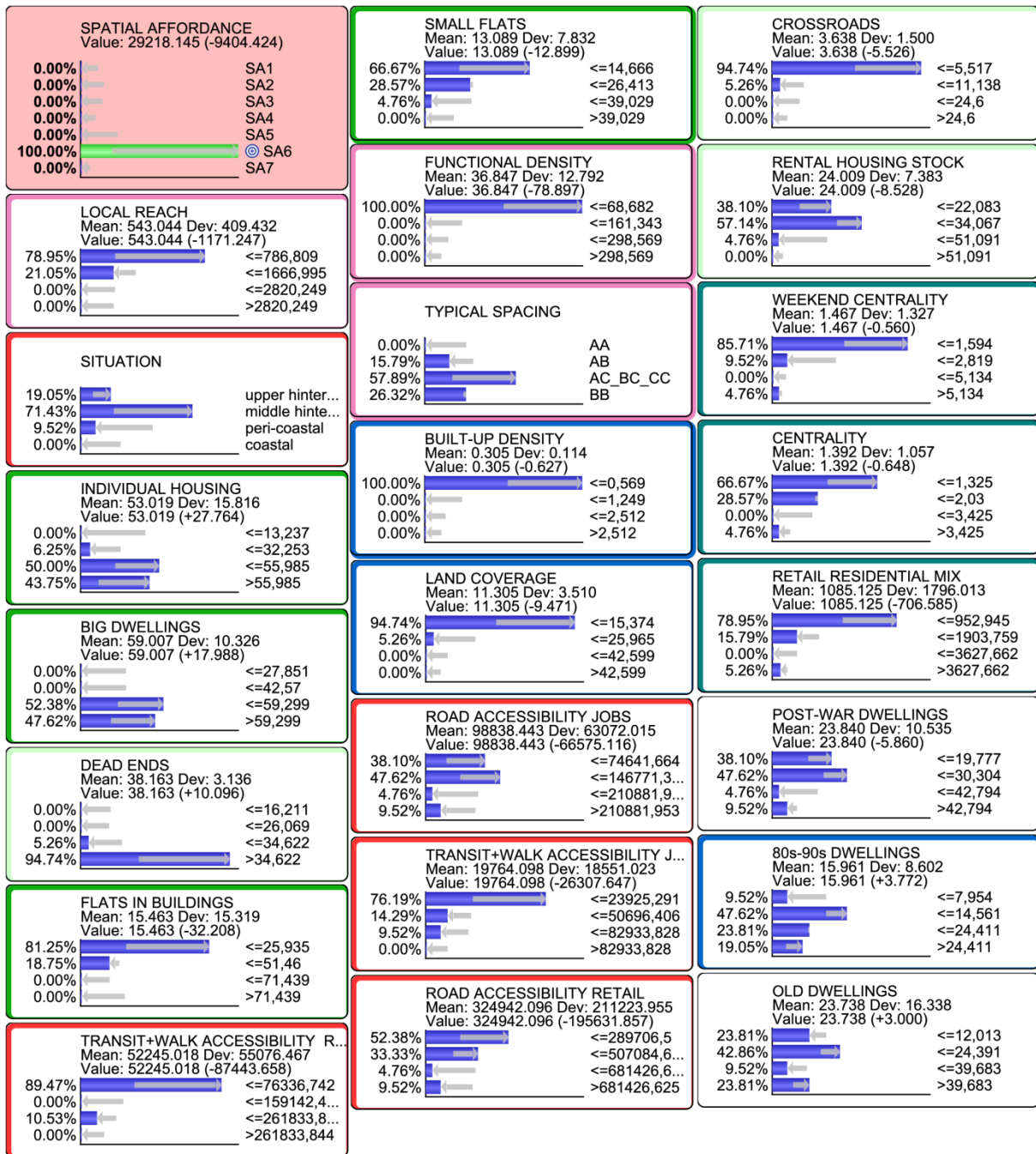


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 2 Figure C4 – Probabilistic profile of cluster SA4- Pericentral, discontinuous, residential or mixed urban fabric,
 3 with varied housing.

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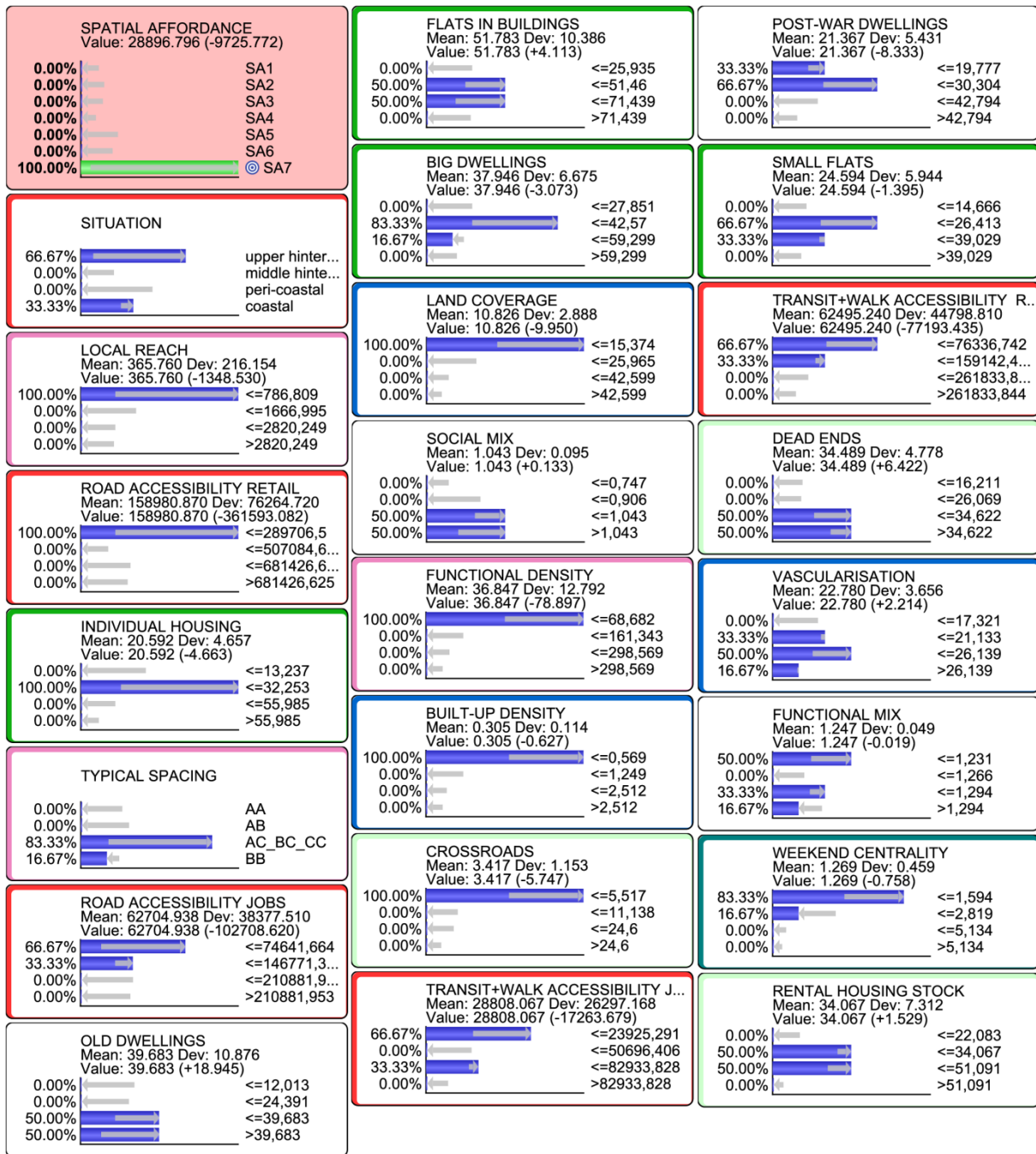


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 2 Figure C5 – Probabilistic profile of cluster SA5- Pericoastal suburban fabric with high road accessibility.
 3



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Figure C6 – Probabilistic profile of cluster SA6 - Residential, individual-home suburbs with low accessibility in the middle hinterland.

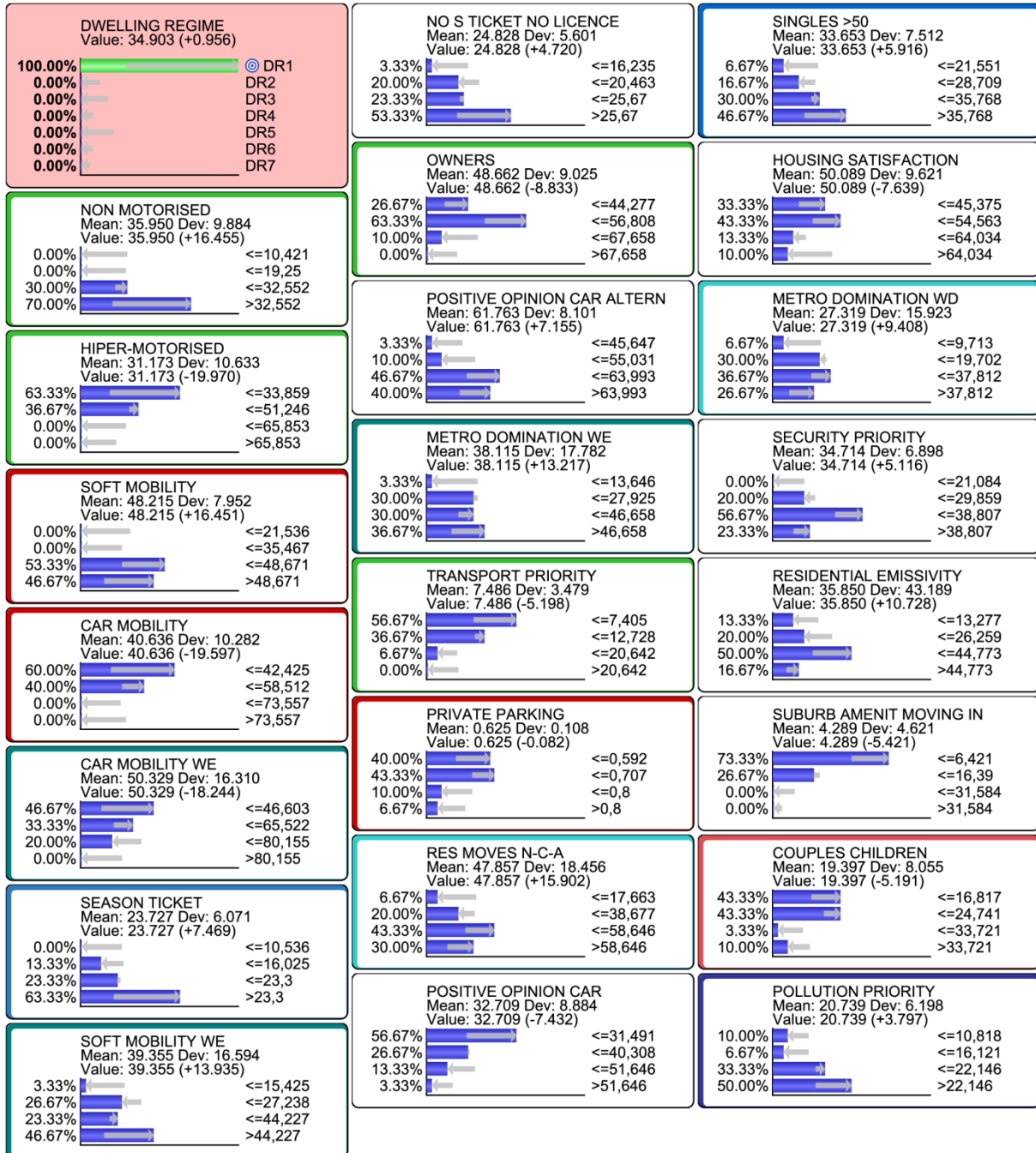


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 2 Figure C7 – Probabilistic profile of cluster SA7 - The upper hinterland with distant, difficult to access villages
 3 and mixed housing.
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1 Appendix D – The Probability Profiles of Dwelling Regime Clusters

2 Reading key: variables are listed in descending order of mutual information with the considered cluster. Only the
 3 most important 23 variables are shown. Colours regroup variables according to underlying synthetic factor.

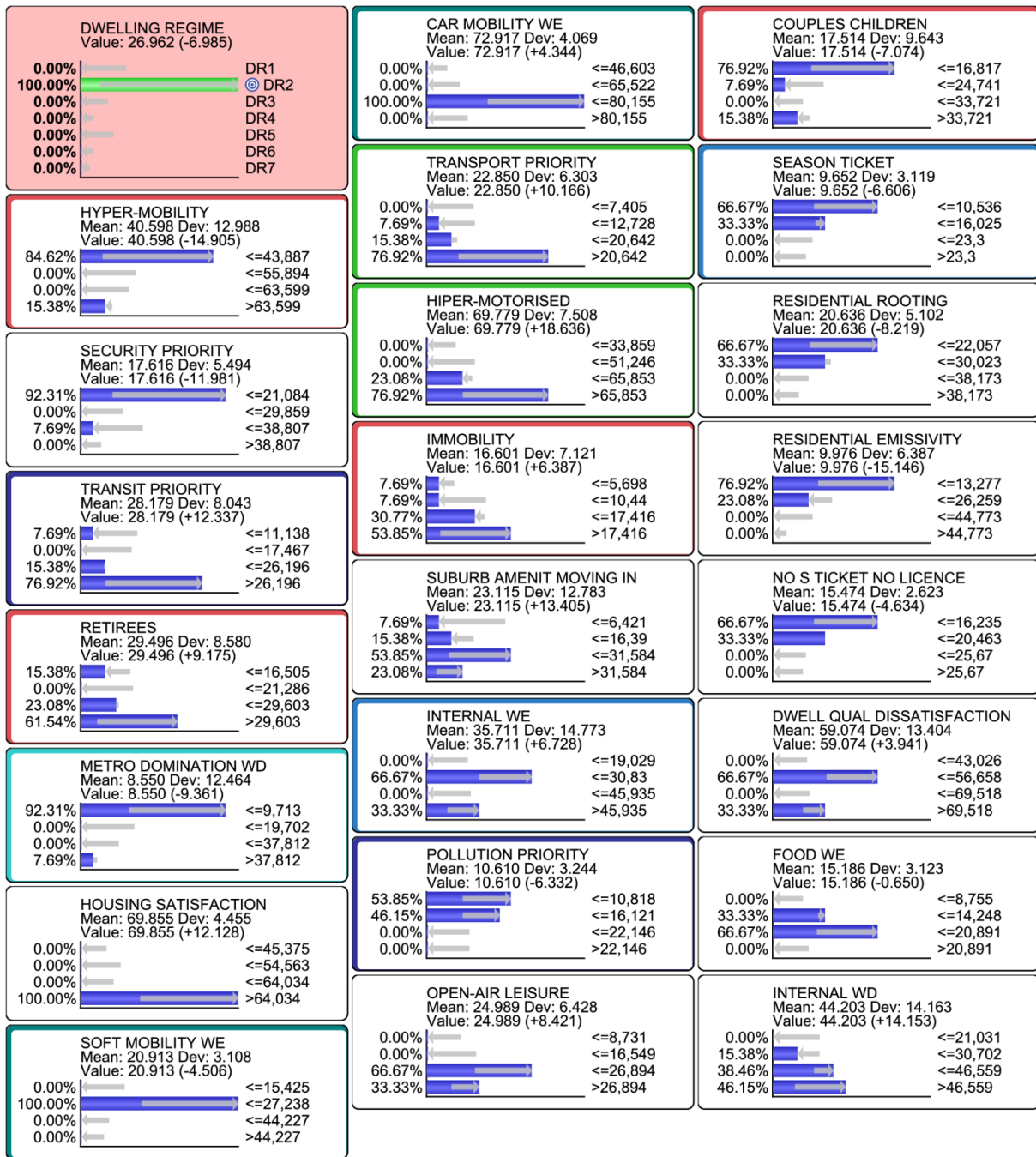
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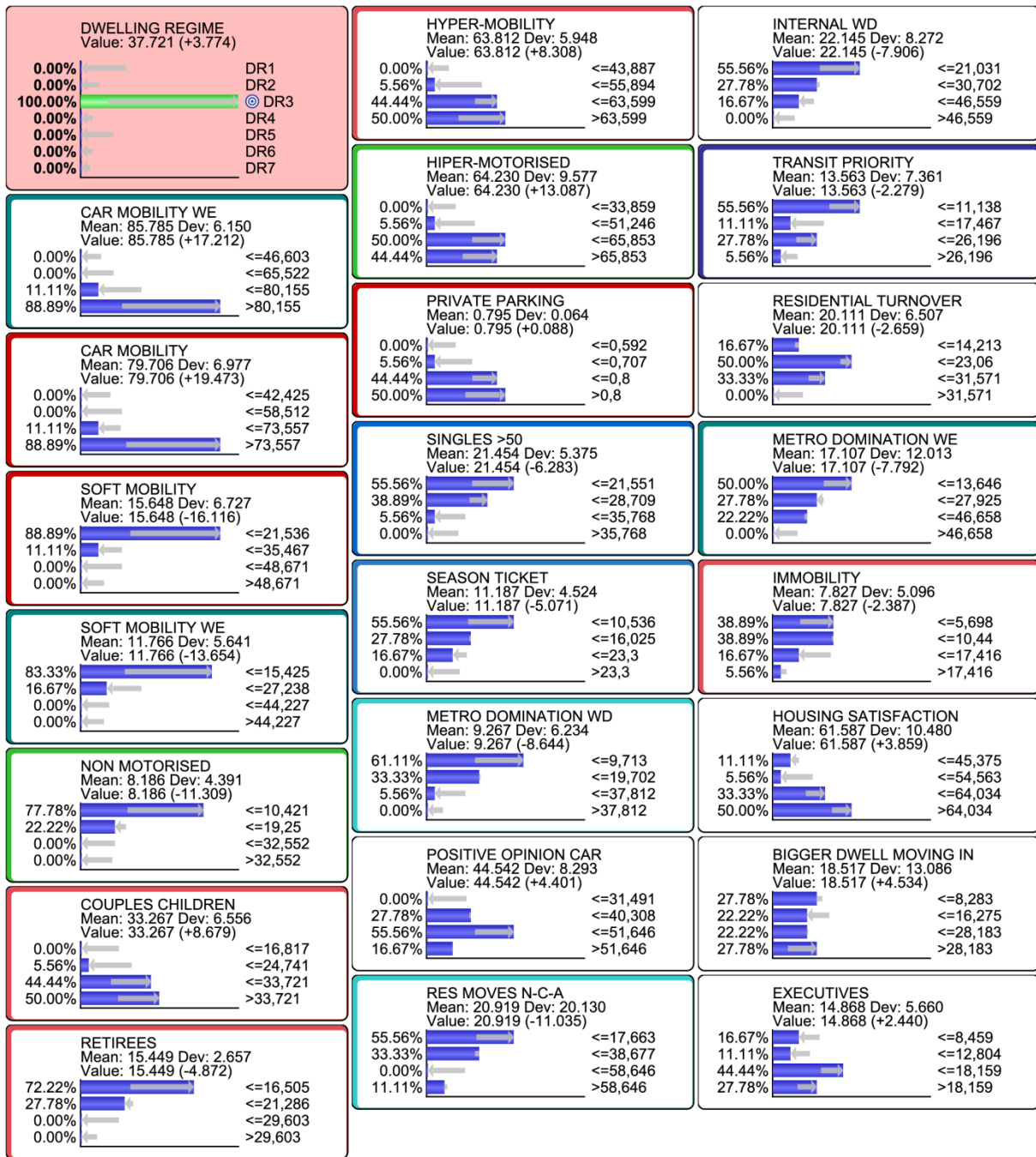
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6 Figure D1 – Probabilistic profile of cluster DR1 - Places of urban lifestyles and diversity.

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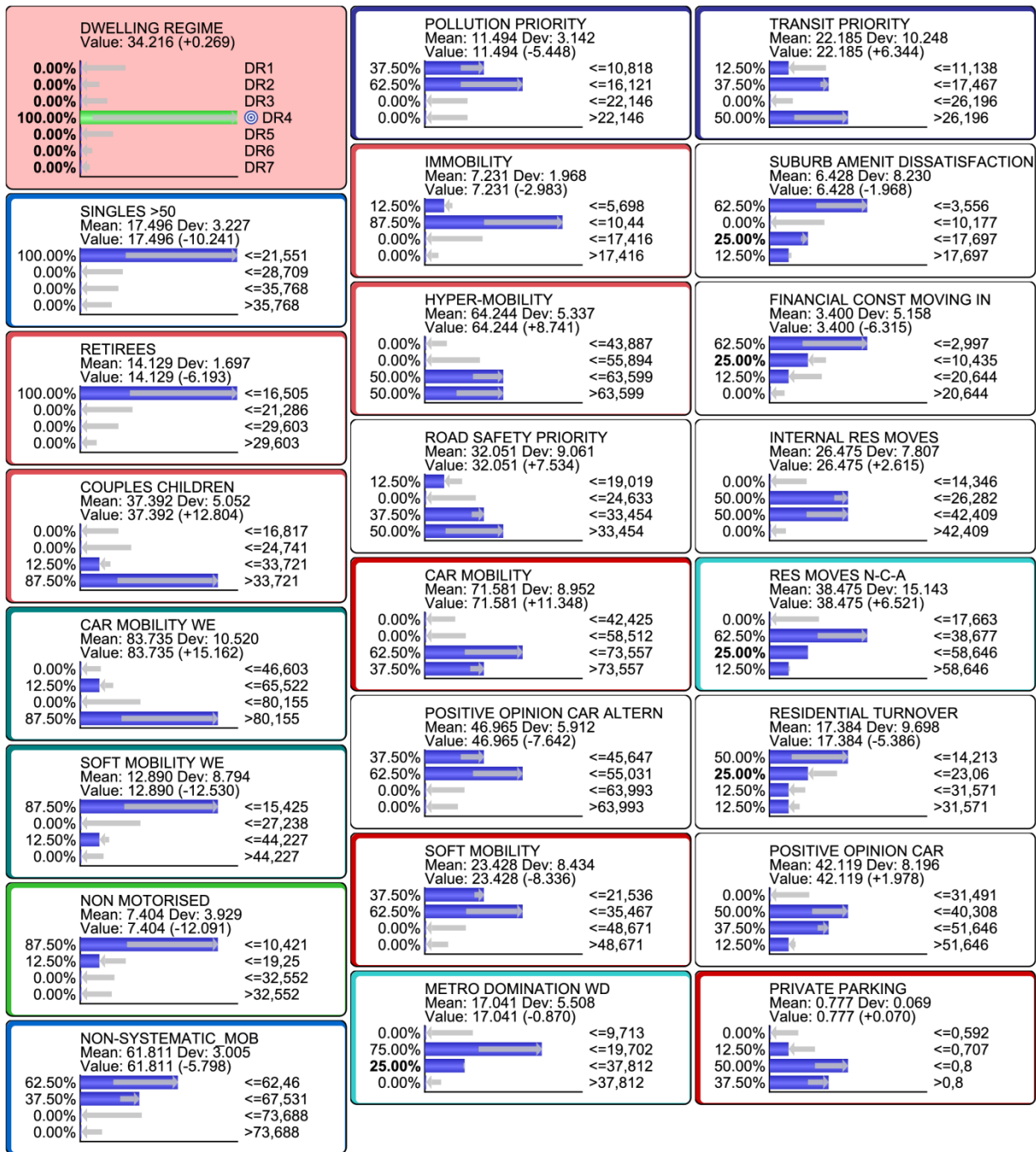


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 2 Figure D2 – Probabilistic profile of cluster DR2 - Places of village lifestyles, anchored to environmental
 3 amenities.
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Figure D3 – Probabilistic profile of cluster DR3 - Places of automobile-dependent families.



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2 Figure D4 – Probabilistic profile of cluster DR4 - Places of families critically accepting automobile-dependency.

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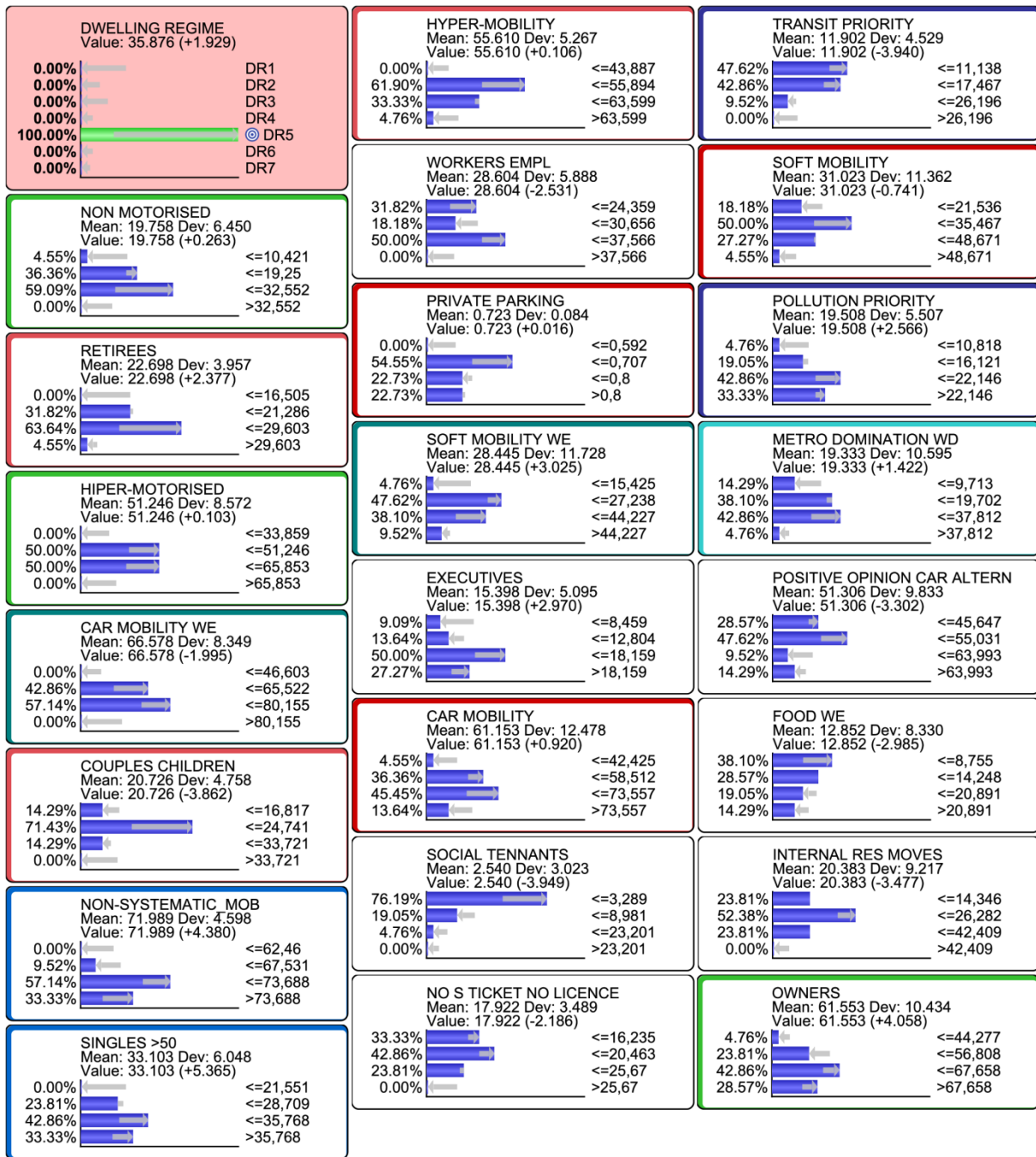
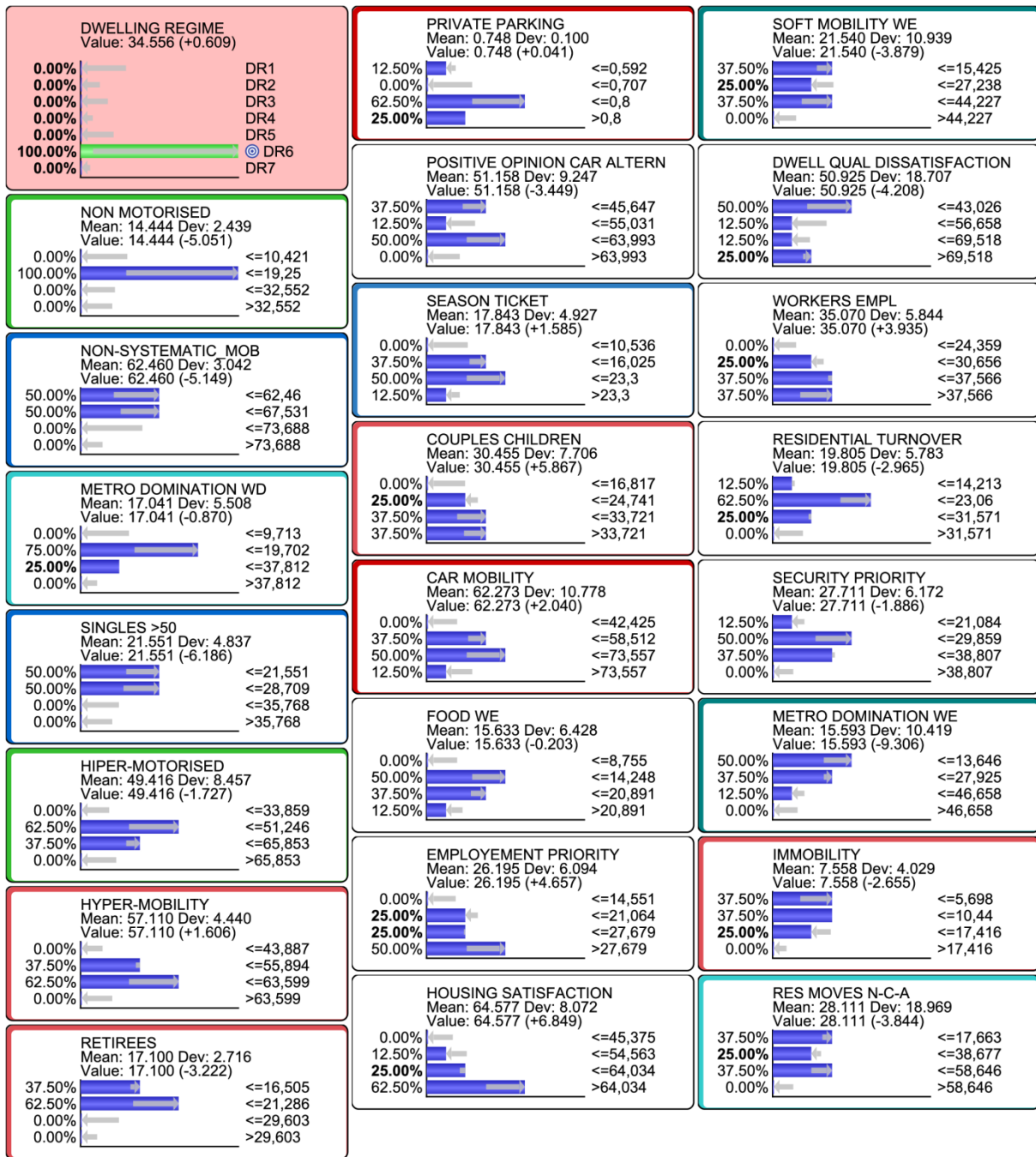


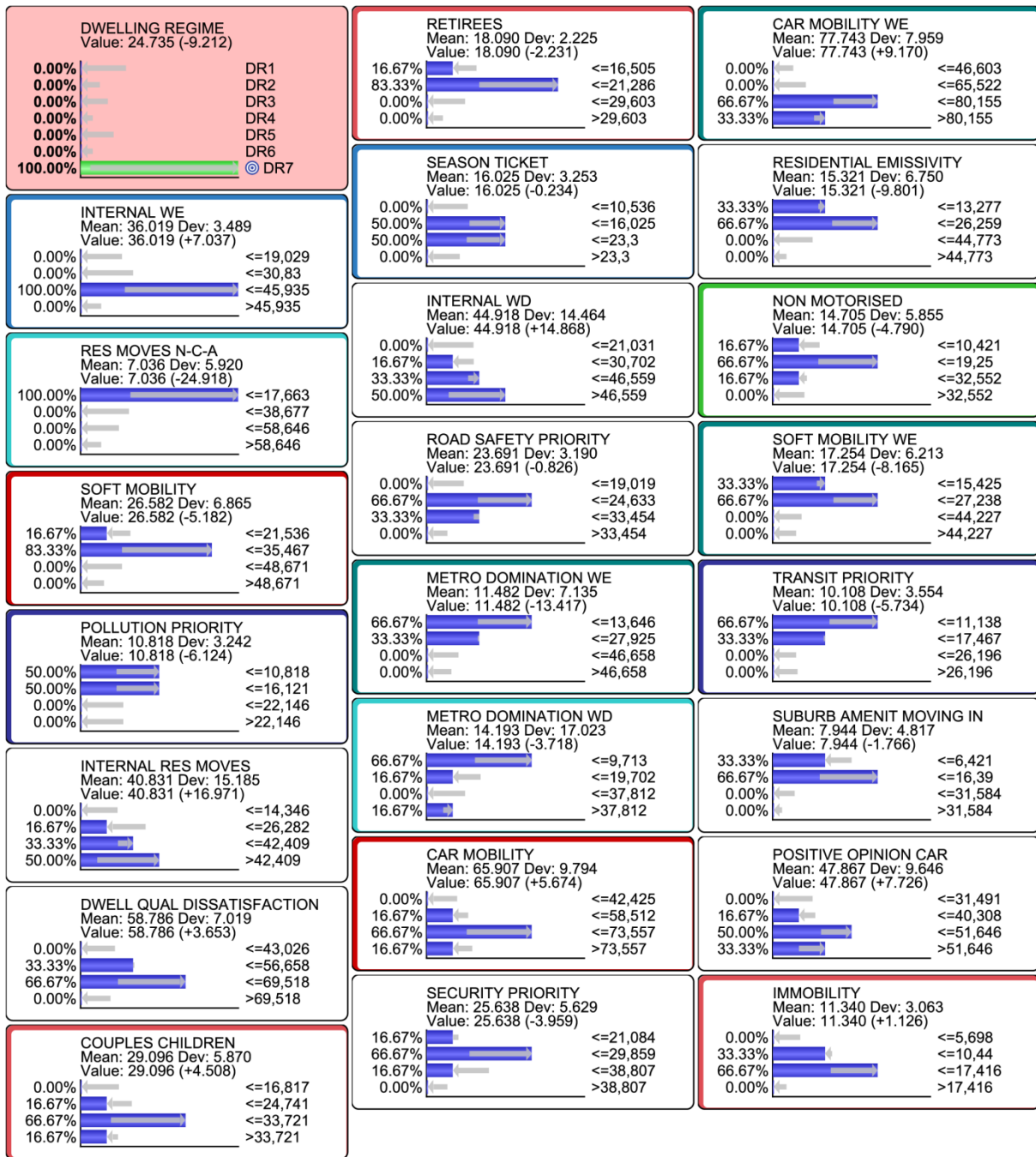
Figure D5 – Probabilistic profile of cluster DR5 - Places of wealthy freely mobile households.



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2 Figure D6 – Probabilistic profile of cluster DR6 - Places of families with intermediate behaviours.

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Figure D7 – Probabilistic profile of cluster DR7 - Mixed places with internal dynamics and automobile dominance.