# Quantifying Remoteness - A GIS Approach

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**Presented at SIRC 99 – The 11th Annual Colloquium of the Spatial Information Research Centre**
**University of Otago, Dunedin, New Zealand**
**December 13-15th 1999**

## ABSTRACT

The need for generalised measure of remoteness for service planning and funding, reporting and research has long been recognised in Australia. The Accessibility/Remoteness Index of Australia (ARIA) was developed by the National Centre for Social applications of Geographic Information Systems (GISCA) in partnership with the Australian department of Health & Aged Care. This approach uses distances to service centres as the basis for quantifying service access and hence remoteness. It uses GIS technology to combine road distances to population centres of various sizes, as a measure of service access, to develop a standard measure of remoteness at community level (aggregable to larger units) that is suitable for a broad range of applications. To facilitate access to the index, an Internet application has been developed which allows users without special skills to interrogate maps to obtain remoteness scores for localities or higher-level areal units.

***Keywords and phrases*:** remoteness; service accessibility; road distance; rural health; GIS.

## 1 FOREWORD

The Accessibility/Remoteness Index of Australia (ARIA) project has been sponsored by the Department of Health and Aged Care in an attempt to obtain a standard classification and index of remoteness. The Index and

Classification supersedes the Rural, Remote & Metropolitan Areas classification (RRMA), produced in conjunction with the Department of Primary Industry and Energy (DPIE) in 1994, for internal Departmental use; in addition, the Department is proposing ARIA for adoption as a national standard.

## 2 ACKNOWLEDGMENTS

The Commonwealth Department of Health and Aged Care funded this work. Special acknowledgment is made to the Australian Surveying and Land Information Group (AUSLIG) for access to their 1:250,000 Topographic series infrastructure data set and the High Performance Computing Centre at the University of Adelaide who provided free access to their computing resources to undertake the analysis.

## 3 BACKGROUND

There has been an increasing concern over a number of years about the difficulties faced by Australians living in rural and remote areas in accessing services that most Australians take for granted. Government in particular has been interested in finding out more about their circumstances and needs, and targeting assistance accordingly.

However the concept of remoteness itself has lacked precision. It is clear that central to most people's understanding of the concept is distance, eg

> Remote: …Far away, far off, distant from some place, thing or person; removed, set apart…[1]

There are, however, a number of aspects to the concept of remoteness—not all of which are negative.

For the purposes of the project the concept of "remoteness" had to be refined to the extent that it could be quantified, as a necessary step to identifying the needs of people living outside metropolitan areas. With access to an objective measure of "remoteness", services could more easily be designed and targeted to address priority areas of need.

Effort has focussed on disadvantage in terms of accessible services, especially those routinely available to people in metropolitan areas. Remoteness has largely come to be identified with lack of accessibility[2] to services.

The Overview of the 1994 *Rural, Remote & Metropolitan Areas classification* (RRMA) commenced with the words:

> This classification has been developed in response to the growing need for knowledge and information about issues of concern to rural and remote Australia. [p1]

The RRMA has itself been used as the basis for a number of government programs targeted at "Rural and Remote" Australians, in several Commonwealth Agencies. The Classification has also formed the basis for building up the information base in this area, notably in the recent AIHW publication *Health in Rural and Remote Australia*. In the process, however, it has become apparent that there is a need for a formal national standard, which would take advantage of the significant increases in the availability of data and information technology, and could be used in the production of official statistics.

The RRMA classifications treated the terms "remote", "rural", "urban", and "metropolitan" as values of a single categorical or ordinal variable. The ARIA approach, by contrast, has been to isolate the concept of "pure" remoteness as a continuous variable measured in terms of accessibility.

ARIA is a culmination of effort over a number of years directed toward quantifying remoteness, to serve as both an analytical and a policy tool.

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[1] Shorter Oxford Dictionary.

[2] The term "accessibility" is generally used rather than "access", as the approach has been to consider the extent to which services are *able* to be accessed, rather than the extent to which people are *actually* accessing them.

## 3.1 Approaches to conceptualising remoteness

Earlier classifications of non-metropolitan areas in Australia were carried out largely on the basis of the related variables of population density, intensity of land use and habitability. However, in the 1980s there emerged an emphasis on attempting to subdivide the non-metropolitan parts of Australia on the basis of their degree of *'remoteness'*. This reflected recognition of the locational disadvantage suffered by Australians residing in areas of low accessibility to services, and the need to adopt different types and standards of service provision to overcome these barriers. Accordingly a number of attempts were made, mostly by Commonwealth agencies, to recognise and delimit zones of remoteness in Australia.

In conceptualising remoteness there appear to be two separate approaches:

- A *geographical* approach which defines remoteness in terms of environmental parameters influencing access. Remoteness is defined in terms of the physical distance separating the base spatial unit (eg Localities, Statistical Local Areas (SLAs), Census Collection Districts (CDs)) from nodes of activity. The major focus is on how distance restricts opportunities for interaction.
- A *sociological* approach, which concentrates upon how perceptual, behavioural and socio-economic characteristics of inhabitants of an area impinge upon accessibility to services.

While it is clear that socioeconomic disadvantage can greatly exacerbate locational disadvantage, in a general classification system it was considered preferable to adopt an unambiguously geographical approach to defining remoteness. Including locational and socioeconomic disadvantage in a single measure would create ambiguity about which of these elements has more effect on accessibility in a particular area, leading to difficulties in developing appropriate programs to overcome or ameliorate the disadvantage.

It is also necessary to separate the variables in order to investigate their relationship, ie the extent to which remoteness is associated with socioeconomic status.

The point here is not that socioeconomic factors should not be taken into account in studies of accessibility to individual services. Indeed they should be taken into account in such studies. However it would seem that a general index or classification of remoteness would be more suitable for a wide variety of applications if unambiguously based on the distance people from an area have to travel to obtain services. Since it is recognised that people will differ in their ability to meet these costs, program interventions should target groups as well as areas.

Faulkner and French (1983) defined remote communities as

> spatially defined communities which are distant from urban centres where supplies of goods and services, and opportunities for social interaction are concentrated.

Thus regions with urban centres may still be remote if the range of goods and services available at those centres is limited and the region is distant from larger urban centres.

## 3.2 Commencement of the ARIA project

In 1996-97 the Australian Bureau of Statistics undertook a comprehensive review of its Australian Standard Geographical Classification (ASGC), used in all government and many private data collections.

The National Key Centre for the Social Applications of Geographical Information Systems at the University of Adelaide (GISCA) was commissioned by the ABS to assist the review in the following areas:

- criteria used to delineate urban areas;
- criteria used to describe remoteness; and
- advice on other classificatory systems in the new ASGC and their conceptual basis.

This work was completed in May 1997; GISCA published a substantial report (Hugo 1997). One of its recommendations was to develop methodologies, using GIS technologies, to measure remoteness in Australia.

The ABS did not proceed with many of the recommended changes to the ASGC (including defining remoteness). Subsequently the then Department of Health and Family Services asked GISCA to undertake a remoteness project building on the approach taken in the RRMA but using GIS technology and greater data

availability to address some of the concerns which had arisen, and allow validation of some apparently arbitrary aspects.

## 3.3 Aims

If the index and classification were to be accepted as national standards, it was considered that the approach would need to be

- **Comprehensive**, dealing with all non-metropolitan areas of Australia without producing anomalous results or the need for artificial "adjustments";
- Sufficiently **detailed** (in terms of level of application) to avoid anomalies arising from aggregating heterogeneous areas;
- As **simple** as possible, given the computational requirements arising from the above, ie avoiding methodological refinements that made little substantive difference to the outcome;
- **Transparent** and **defensible**—not a "black box";
- Intuitively **plausible** in its results—it should make sense "on the ground"; and
- As far as possible without compromising the above, **stable** over time: the remoteness score of an area should change if and only if it becomes more or less remote (eg a nearby population centre grows or shrinks significantly), not simply due to administrative boundary changes.

# 4 METHODOLOGY

## 4.1 Population as a proxy for service availability

The assumption that the range of services available from an urban centre depends on its population underlay the whole approach of developing a *standard* geographical classification. However little empirical validation of this assumption had been done.

To test this, a database of populated localities was constructed, containing service and population information. Service information was obtained from Telstra white and yellow pages telephone directory . These services were then grouped into 20 categories on the basis of the Australian and New Zealand Standard Industry Classification (ANZIC) industry code. Analysis showed a relationship between population size and the availability of many commercial services in terms of number and type of services. This was particularly evident in the health and education service sector where high level health (major hospital services) and a large range of post secondary education courses were only available in cities with large population base. The range of health services and education services that were available in a location subsequently decreased as the population base declined. Additionally, there appeared to be distinct categories of centres clustered in particular population ranges, with natural breaks in the population distribution. On the basis of this analysis, the following categories of "service centres") were identified:

| | |
|---|---|
| A: | more than 250,000 persons |
| B: | 48,000 - 249,999 persons |
| C: | 18,000 - 47,999 persons |
| D: | 5,000 - 17,999 persons |

It was assumed services available at smaller centres are also available at larger centres, so that if a populated locality is close enough to a larger centre, distances to other, smaller centres cease to have an effect on its access to services and hence remoteness. The detailed results of this analysis has not yet been published, but it is planned to do so in the immediate future.

## 4.2 Road distance as an access indicator

Other attempts at classifying remoteness have attempted to identify the number of services within a given time or distance radius.

This approach measures access to a range of services, and hence the level of choice available in a given area. In the Australian context, however, choice is seen as less important than having minimum access to at least some services. Access to the second service of a given type is much less important than access to the first.

It would be difficult to combine the approach of including distances to centres of various sizes—seen as an essential element of a multipurpose or standard classification—with consideration of multiple centres in each category. Further, to do so would certainly violate the aim of simplicity, both in theory and practice. Thus ARIA focussed on *minimum* distance to centres in various categories.

Outside metropolitan Australia, road transport is the predominant mode of transport. It is true that not everyone has access to private motor vehicles; however the function of ARIA is to provide a measure of the accessibility of an area, not to provide a complete picture for individuals. Public transport may also be road-based (buses).

While air transport is increasingly relevant to delivery of some services, it is generally an exceptional rather than the principal mode of access. The case of areas which have no road access to some or all categories of service centre is covered under 4.6 "Special cases: Islands" below.

The basic spatial unit for which remoteness was measured was the populated locality, derived from AUSLIG's 1:250,000 topographical series. GIS network analysis was used to calculate actual distance travelled by road (rather than straight-line distance, as in RRMA) from each of the populated localities to each of the service centres (201 centres). This avoided anomalies in areas where natural barriers (mountains or waterways) constrained access to population centres.

## 4.3 Populated Localities

The populated locality was chosen as basic spatial unit for analysis. This is derived from populated place as defined in the infrastructure layer of the AUSLIG 1:250,000 topographical series. The use of populated localities (11,338 locations) as the basic spatial unit for the calculation of ARIA values helps overcome the problems of internal heterogeneity in the large SLAs, Postcodes and CDs in much of non-metropolitan Australia.

## 4.4 Road type

The distance measures did not take into account the type of road. It was felt that there was no clear quantifiable relationship between road type and travel time; road quality could be subject to short-term variation; and any detailed analysis incorporating road type would be unlikely to affect the outcome materially.

## 4.5 Distances within service centres

The methodology used treats services as located at the GPO of each of the service centres. As well as being a practical necessity, this makes little difference to accessibility measures for people living outside service centres.

For people living *within* service centres, however, their road distance to the GPO may have little bearing on service accessibility. Further, public transport would need to be considered. However there is undoubtedly scope for productive studies of intra-urban service access issues. Where a populated locality was within a service centre in the relevant category, it was given a distance value of zero for that category.

## 4.6 Special cases: Islands

The separation of islands from the mainland road network resulted in most islands, with the exception of Tasmania, having no road distance measurements for any of the distance class categories. Two methods to assign distance values to island localities were developed to deal with this problem, one for Tasmania, and one for all other islands with identified localities.

The method used to calculate remoteness for Tasmania used the Class B distances, calculated to Hobart and Launceston, and added a factor that would account for the distance and cost of travel between these centres and Melbourne, the closest Class A centre. That factor was 500km.

The approach for other islands was based on the assumptions that

- all islands separated from the mainland (ie without bridges) were more remote than any point on the mainland equally distant from urban centres; and
- the additional time of travelling from an island to the mainland would initially be high and then taper off as the distance travelled increased.

A weighted distance measure was developed for island localities. **Table 1** shows the graduated weights that were used. The weights were applied to the distance measurement from the centroid of island localities to the closest mainland point. The island locality point or points would then assume the distance values of that closest point with the addition of the weighted distance measurement.

**Table 1: Graduated weighted distance used for islands.**

| Distance (km) | Weight |
|---|---|
| 0-10 | 10 |
| >10-20 | 5 |
| >20-50 | 3 |
| >50 | 2 |

## 4.7 Calculation of minimum distances

The minimum distance from each populated location to the nearest service centre in each of the four categories was extracted from the base distance measurements. This gave four measurements per locality, each representing the minimum distance to a service centre in a particular category. (Populated localities within a service centre in the relevant category were given a distance value of zero for that category, as per 7.4.2).

This was further adjusted by substitution of minimum distance to larger centres for minimum distance to smaller centres where the former was less.

Each measurement recorded the origin and the destination locality and the distance.

**Fig 1** shows the populated localities, service centres, and major road network.

## 4.8 Combining distance scores

Clearly the four index values cannot be simply summed, or else Category A distances would overwhelm the effect of other distance variables.

Combined "standardised" scores (ie converted to a common mean and standard deviation) would be valid for normally-distributed variables, but the ARIA distance values are strongly skewed.

Accordingly it was decided to convert each distance to a ratio to the mean (ie divide by the mean distance travelled from all populated localities for that distance category) in an attempt to standardise the distance values across each of the four levels.

The ratio of the minimum distance to each of the four service centre levels to the mean was calculated for each of the 11,338 populated locations. Distances for localities *within* service centres in the relevant category were then set to zero.

Even with the scores converted to ratios to the mean, in some cases the distance to the nearest service centre in a particular category still overwhelmed the effect of distance to centres at other levels. To remove the effects of extreme values from the index, therefore, a threshold (expressed as an integral multiple of the average distance for a category) was applied. The threshold ratio could not be set too low if it was to distinguish the most remote areas in terms of access to services. Accordingly, a threshold of three was chosen. This produced threshold-limited ratios ranging from 0 to 3.0 for each of the four categories, making them more comparable than the previous simple ratio approach.

A single remoteness measurement for each populated location was calculated by the addition of the ratio values for each of the four levels of centre, giving a continuous variable from 0 to 12 as the measure for remoteness. Figure 1 shows the ARIA values at all populated localities in Australia, service centre locations and the major road network.

## 4.9 Interpolation to a 1km grid

The limitation of an index based only on "inhabited localities" was that, while precise, it was not exhaustive—most of Australia, and many inhabitants of the remotest areas, would not be covered.

This was overcome by using a "grid-cell" approach: the values of remoteness were interpolated onto a 1km regular grid across the whole of Australia, using an Inverse Distance Weighted algorithm. For each cell, this weighted the remoteness values of the six nearest localities by the distance to each, to assign a remoteness value to the cell. (Cells within a service centre in the relevant category were given a distance value of zero).

Figure 2 shows the calculated grid overlaid with remoteness contours.

### 4.10 Aggregation to higher-level geographic units

Although the ARIA was defined primarily at the 1km-grid-square level, for some applications such as production of national statistics, scores of higher-level regions (eg SLAs, Postcodes) need to be determined.

There was some debate about whether this should be done on a population-weighted basis, with more populous areas having more influence, or as a straight arithmetic mean of grid cells which lay wholly or predominantly within each higher-level unit.

The approach of ARIA in particular has been to view remoteness as geographic, ie a characteristic of areas rather than populations, which supports the unweighted approach. In addition:

- Population data for grid cells was unavailable (SLA and Postcode values could have been calculated from CD estimates—but CD values would themselves have to be estimated on an unweighted basis);
- Stability—a population-weighted index would be affected by changes to the population distribution within an SLA, even if neither the SLA boundary nor the index value for any grid cell within the SLA changed; and
- Simplicity was a consideration.

Accordingly, calculations were done on the basis of a simple arithmetic mean, including all grid cells that were wholly or predominantly within the larger unit.

From the regular grid, an average value for remoteness was calculated for each collection district unit, postcode area and local government area in Australia.

## 5 REMOTENESS CLASSIFICATION

Although a continuous index is ideally suited to some forms of research, the publication of statistics, and some forms of administrative application, require discrete categories. In particular, a number of government programs apply to people or services in "remote" areas, on the basis of the RRMA classification. An analysis was undertaken of the distribution of the ARIA values at the locality level. It was decided for classification purposes to use natural beaks in the distribution as the break points for the classification.

This approach gave the following categories:

- Highly Accessible (ARIA score 0 - 1.84) - relatively unrestricted accessibility to a wide range of goods and services and opportunities for social interaction
- Accessible (ARIA score 1.84 - 3.51) - some restrictions to accessibility of some goods, services and opportunities for social interaction
- Moderately Accessible (ARIA score 3.51 -5.80) - significantly restricted accessibility of goods, services and opportunities for social interaction
- Remote (ARIA score 5.80 - 9.08) - very restricted accessibility of goods, services and opportunities for social interaction
- Very Remote (ARIA score 9.08 - 12) - very little accessibility of goods, services and opportunities for social interaction

## 6 DISSEMINATION

The ARIA methodology ARIA has been described in more detail in a Department of Health and Aged Care Occasional Paper.

It is envisaged, however, that the primary vehicle for disseminating ARIA data in particular will be the Internet. Lists of ARIA scores and categories for Populated Localities, SLAs and postcodes are presently available on the

Department's Website, together with a utility which allows users to search for values of a particular locality or areal unit.

To facilitate access to the index, an internet application has been developed which allows users without special skills to interrogate maps to obtain remoteness scores for localities or higher-level areal units.

It is envisaged that area data will ultimately be made available as part of a broader database of information about localities and service availability on the Internet.

## 7 THE FUTURE

As noted above, ARIA represents an attempt—perhaps the first—to deal with remoteness in terms of access as a separate dimension of areas, aside from other variables such as population, demographic characteristics or population density of the area classified. This in fact increases the scope for examining the relationship between remoteness and such variables.

Greater flexibility is being demanded in terms of the spatial units for which data are provided. In the longer term it is likely that many agencies including the ABS will adopt a practice of "geocoding" (coding to latitude and longitude) their data collections. Spatial referencing of this information to particular points on the earth surface would allow the use of totally flexible boundaries. In the meantime however, we need to have the most appropriate and useful spatial units for the dissemination of data.

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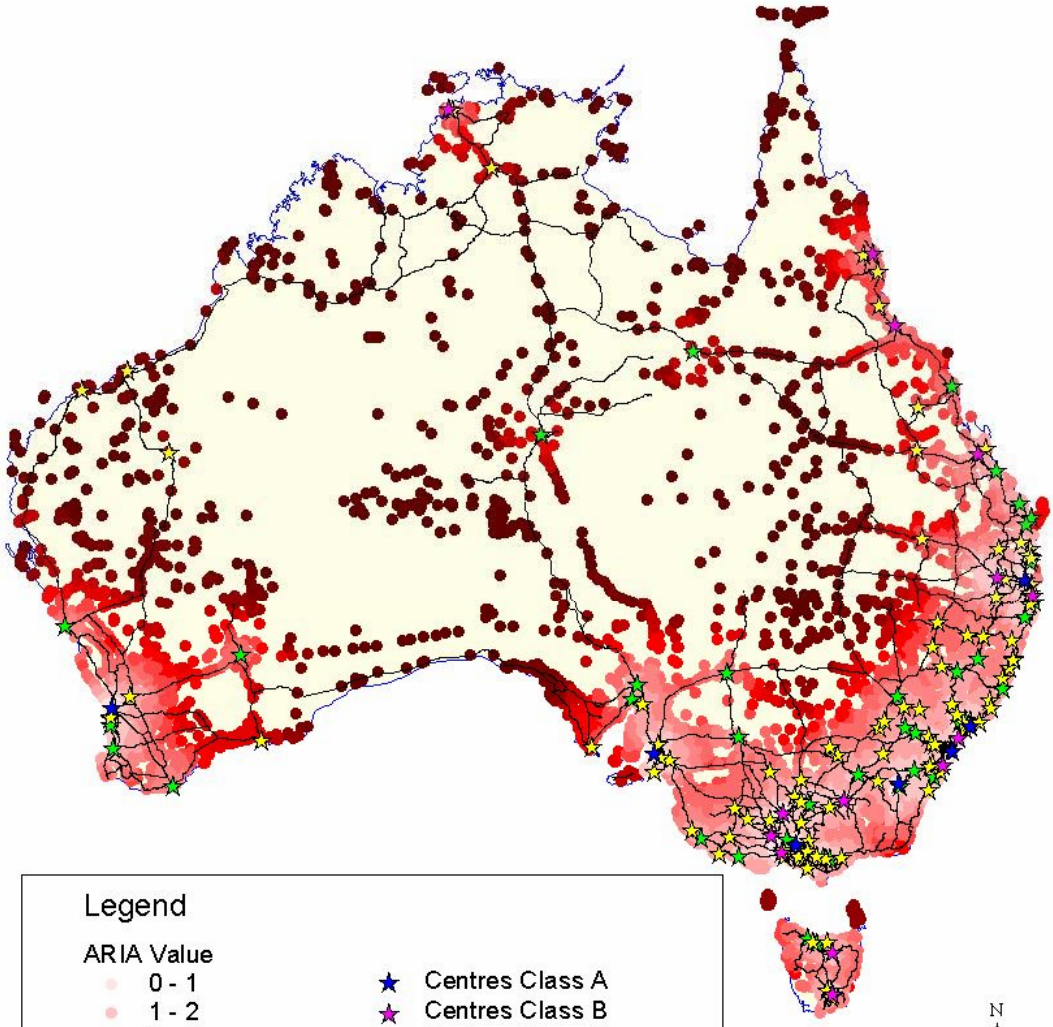
*Figure 1: Populated Localities, Service Centres, and Major Road Network.*



Legend

ARIA Value

- 0 - 1
- 1 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- 7 - 8
- 8 - 9
- 9 - 10
- 10 - 11
- 11 - 12

- Centres Class A
- Centres Class B
- Centres Class C
- Centres Class D
- Major Roads

N
W E
S

200 0 200 400 Kilometers

Maps Prepared by GISCA
The University of Adelaide
December 1998

*Figure 2: ARIA Values Interpolated to 1km Grid, with Contours.*