and could be used as a building material.

More broadly, the general approach of hydrogen-plasma reduction is versatile and potentially applicable to other materials. The next step should be to investigate its use for extracting iron from resources such as low-grade iron ores and the waste (tailings) from the processing of iron ore. These resources are available in even greater quantities than is red mud, and some of them, such as iron-ore tailings, are equally hazardous to store.

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Economics

Urban youth most isolated in largest cities

Victor Couture

GPS data reveal that young people encounter fewer individuals from diverse groups than do adults. The isolation of young people is exacerbated in larger cities, and for those living in poverty.

Cities exist to bring people together. Shared urban spaces, such as public amenities or commercial venues, offer settings for social interactions – be they for networking, learning or friendship. But the social benefits offered through such interactions are not open to everyone. Writing in *Nature Cities*, Cook *et al.*[1] report that young people living in urban areas often struggle to take full advantage of the benefits of large cities. For instance, young people living in poverty tend to visit venues close to their homes, which are typically frequented by people with similar incomes. The authors' extensive evidence echoes anecdotal accounts, such as those of disadvantaged youths who live in Los Angeles, California, but have never seen the ocean (see go.nature.com/3rpkj3v).

Cook *et al.* used GPS data to document the varied social experiences of people from different demographic groups in the United States. These experiences can be quantified through measures such as racial isolation, which captures the extent to which people from minority groups visit the same shared spaces as those frequented by the majority group. However, GPS data for smartphones capture only the movement of the device, not the characteristics of its owner. Quantifying racial isolation and the closely related measure, income isolation, therefore presents a considerable challenge, which the authors addressed by developing ways of assigning income, race and student status to devices in their sample.

Device owners were assigned a home location on the basis of where their device was at night, and their income group was inferred from data on housing value. The authors gauged whether a device owner was white or non-white from the racial composition of the census block group (the smallest geographical unit used by the US Census Bureau) corresponding to their home location. Individuals were designated as students if the device was frequently at a school on weekdays. Devices belonging to individuals under 16 years old were excluded, so student age ranged from 16 to 18 years old. In this sense, the study uses student status as a proxy for youth.

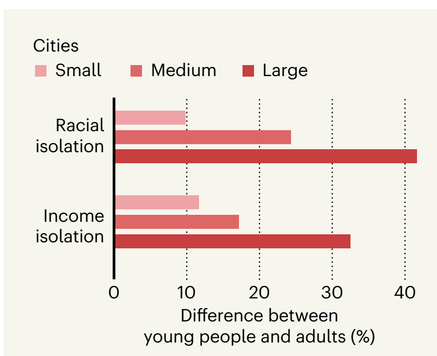

Figure 1 | Isolation experienced by urban youths compared with adults. Cook *et al.*[1] used GPS data to categorize smartphone owners on the basis of their income, race and age. They then quantified the racial and income isolation (which capture the extent to which people encounter members of other groups in shared spaces) experienced by each device owner. They found that young people experience more isolation than adults do, and that the difference between the two groups increases with city size. (Adapted from Table 2 of ref. 1.)

These methods allowed Cook *et al.* to attribute a demographic profile to the owner of each device, and to people in the venues they visited. They used a previously developed measure[2] of income isolation to capture how often people with different incomes are in the same shared spaces. Specifically, an income isolation level of 0.5 means that there are half as many high earners in the venues that low earners visit, on average, as there are in the venues frequented by people with high incomes. Racial isolation is defined similarly.

The disparity in isolation between young people and adults is stark: young people face 21% more racial isolation and 13% more income isolation than do adults. Intriguingly, the gap between these two groups becomes more pronounced in larger cities. Young people in small cities experience around 10% higher racial isolation than do adults, whereas the difference in the largest cities is about 42% (Fig. 1).

Why are urban youths so isolated? Cook *et al.* found that young people spend more time than adults in and near their their homes – a tendency that increases isolation if neighbourhoods are segregated by race and income. Adults typically have more varied daily routines, such as going to retail outlets and restaurants. Adults also tend to have more economic resources, including access to a car, which allows for broader social interactions across the city. This finding offers a nuanced view of how different demographic groups engage with their urban environment. Low-income youths with constrained mobility rarely interact with high earners, and might therefore be missing out on some of the social benefits of living in large cities.

Indeed, the importance of forming local interactions with high earners has already been made clear. A study showed that an individual's upward social mobility can be predicted from how many of their Facebook friends come from affluent backgrounds[3]. And a study that used GPS data demonstrated how interactions in shared spaces can lead to job opportunities[4]. The benefits of socializing with high earners are often not available to youths from low-income backgrounds, who are most in need of urban opportunities but have restricted exposure to people outside of their socio-economic circle.

Clearly, the mere presence of shared urban spaces does not guarantee diverse interactions or address residential segregation. So what can be done to improve urban youths' access to potentially beneficial social interactions? Cook and colleagues' work has exposed the isolation of city-dwelling young people, but solutions to the problem are yet to be found. Given the strong correlation between residential segregation and experienced isolation[2], reducing neighbourhood segregation is an obvious target.

Beyond that, there are three key avenues to improving social opportunities: enhancing mobility, optimizing venues and reshaping preferences. The first involves finding creative ways to encourage youths from disadvantaged groups to venture outside their home neighbourhood — for example, by offering discounted ride-sharing services[5]. Second, specific venues could be conducive to social opportunities, either owing to their location or because they attract a diverse demographic. These venues might be schools, churches or even large shopping centres, if they are located at socio-economic intersections[6].

Finally, a hypothesis known as intergroup-contact theory suggests that repeated exposure to diverse populations can help to change people's social preferences[7]. In that case, encouraging overlapping visits to shared spaces by people from different backgrounds could increase tolerance, reduce social biases and generate further social inclusion[8]. Each of these avenues for mitigating experienced isolation forms an active research area inspired by Cook and colleagues' findings. Equipped with clear insights into which groups face the most isolation, future research should investigate the root causes of the disparities, and develop policies to remedy them.

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Environmental science

Groundwater decline is global but not universal

Donald John MacAllister

Measurements of groundwater levels in 170,000 wells reveal the global extent of groundwater decline. But the data also show that such depletion is not inevitable in a changing climate, providing hope for a resilient water future. **See p.715**

Groundwater is crucial for water and food security because it acts as a climate buffer, sustaining communities and ecosystems that are vulnerable to changes in water availability as a result of climate change. Groundwater is therefore likely to become more important as these changes accelerate[1]. However, humans are affecting its availability, both indirectly through changes in rainfall, driven by anthropogenic climate change, and directly, through overuse[2]. An estimated 70% of all groundwater is used for irrigation[3], a practice that has rapidly increased in the past 40 years[3,4], leading to serious concerns about depletion[5,6]. Satellite observations[7] and models[5] have been used to study changes in groundwater storage, but these approaches have inherent limitations[8,9]. On page 715, Jasechko *et al.*[10] report direct measurements of groundwater levels around the world — a timely and welcome contribution to our understanding of the state of groundwater resources globally.

Jasechko and colleagues have compiled an impressive global data set of groundwater levels over the past four decades from around 170,000 monitoring wells installed in 1,693 aquifer systems, which the authors define as areas underlain by one or more aquifers (Fig. 1). The data are concentrated in roughly 40 countries in which there has been consistent monitoring, but they nonetheless cover about 75% of global groundwater withdrawal. The authors ensured that the data analysed captured real groundwater-level trends by excluding wells measured over a timespan of fewer than eight years. They then used various statistical

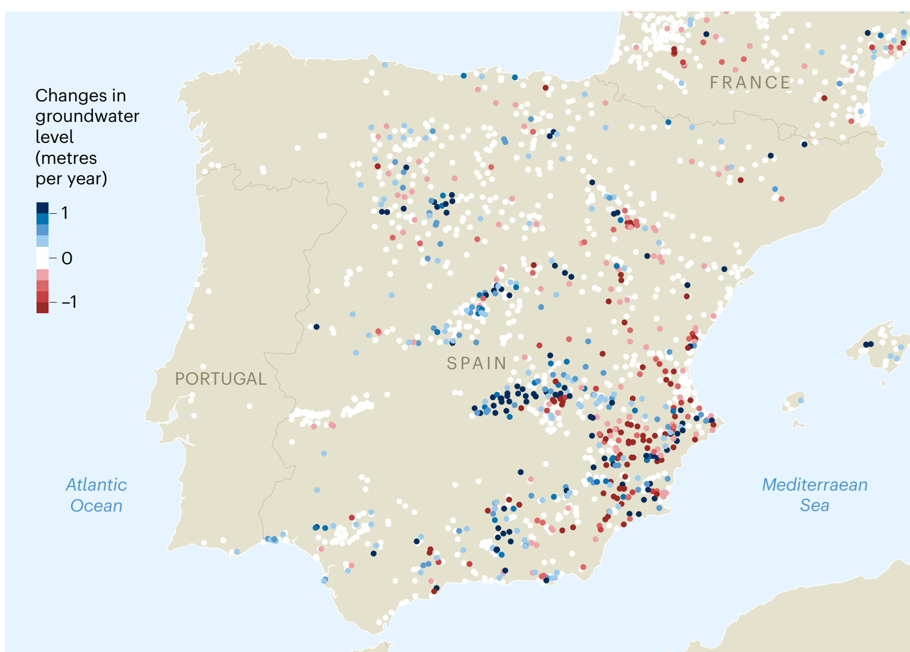

Figure 1 | Groundwater levels across the Iberian peninsula. Jasechko *et al.*[10] compiled measurements of groundwater levels over the past four decades from wells around the world. They found declining levels globally, but also noted that the decline slowed or reversed, or that levels rose continuously in around half of the aquifer systems where monitoring data was available. This variability is evident in this map of groundwater levels measured across Spain, Portugal and France. (Adapted from Supp. Fig. 54 in ref. 10.)