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RESEARCH & POLICY PAPER

# Education Workforce Spatial Analysis in Sierra Leone

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# Executive Summary

This paper is the second in a series developed by Fab Inc. (on behalf of the Education Commission), to help the Teaching Service Commission (TSC) strengthen further the education workforce. It is part of the wider Education Workforce Initiative (EWI) and builds on the *Transforming the Education Workforce* report. Sierra Leone has been a key partner in this initiative. This work builds on a phase one scoping study that focused on options to strengthen the workforce. The other papers in this series cover: Education Workforce Management, Education Workforce Supply and Needs, Education Workforce Recruitment and Matching and Education Workforce Costed Options.

Since its formation, the Teaching Service Commission (TSC) has undertaken a number of initiatives to professionalize the education workforce. One of the key challenges has been in trying to implement a classical, centrally administered education workforce structure in a fragmented system characterised by many compromises. In reality the government is not yet in a situation where they can afford to take all teachers onto the payroll, and even if they could, would have concerns over their quality. Given the disparate needs across the country, there is significant potential for spatial analysis to illustrate where challenges are greatest and highlight possible policy and programme options to address these challenges.

On the surface, there appears a key distinction between the Western Area (i.e. Freetown and the surrounding area) and the rest of the country. However, much of these differences in education indicators (such as pupil-teacher ratios and the proportion of qualified teachers) are skewed by the greater prevalence of private schools in the Western Area. For non-private schools, the differences are less pronounced across districts and instead show much greater variation within districts. In the urban centres across each district, particularly the district capitals, education indicators can closely resemble those within the Western Area. However, outside of these urban centres, education indicators can fall away dramatically, emphasising the issue of remoteness.

Building on a recent report, the TSC has recently adopted a categorisation of remoteness that is incorporated in the new teacher deployment policy. Analysing this categorisation we find that it fits particularly well at the primary level. At the secondary level, there is a smaller share of remote schools and the relationship is not as strong, particularly in terms of pupil-teacher ratios which are not worse in the more remote schools at secondary level. Instead, it seems that remote schools are substituting quantity for quality, and that the more remote a school, the greater the shortage in specialists of key subjects (English, maths and science).

This analysis supports the move towards using remoteness in policy decisions. To do this well, it will be important to mainstream this spatial analysis within the education sector and promote its use throughout the planning process. Specifically, this categorisation should be incorporated into the Annual School Census data and reports, as well as TSC payroll and management data (due to its interaction with recruitment, promotion and transfer as set out in the Teacher Deployment Policy).

To develop this measure further, we also developed a method of analysing the distance from schools to the nearest urban centre, both by straight line distance, but also crucially by routed distances along roads, which takes into account the routes around features such as rivers and hills. Using this routed measure, we also find a drastic drop off in many education indicators at schools that are more than 5km (an hour walk) away from urban centres.

Building on the learning teams concept developed in the Education Commission's *Transforming the Education Workforce* report, we propose an option for reducing the share of secondary schools that lack key subject specialists. This option uses spatial analysis to identify schools that are lacking key subject specialists that are within 5km of a school that has an under-utilised subject specialist in that area. Sharing these teachers across schools could reduce the share of secondary schools that lack key subject specialists by up to a quarter in a low-cost fashion, an option that will be costed and proposed in further detail.

Whilst enrolment is fairly universally high across the primary level, we find a much greater variation across the country at junior secondary and particularly senior secondary level. This highlights that workforce planning will have to take into account that a greater number of teachers will be required in the less-served areas as secondary enrolment increases. These differences in enrolment are closely related to the average distances of the population to secondary schools, which emphasises the importance of greater use of spatial analysis in planning, and particularly catchment area planning going forwards.

# Education Workforce Initiative Overview

This paper is the second in a series developed by Fab Inc. (on behalf of the Education Commission), to help the Teaching Service Commission further strengthen the education workforce. It is part of the wider Education Workforce Initiative (EWI) and builds on the *Transforming the Education Workforce* report. Sierra Leone has been a key partner in this initiative. This work builds on a phase one scoping study that focused on options to strengthen the workforce.

The second phase provides succinct evidence products on specific research areas to guide a policy dialogue on aspects of the education workforce in Sierra Leone, to be held in Freetown. Figure 1 summarises the relationship of these papers to each other:

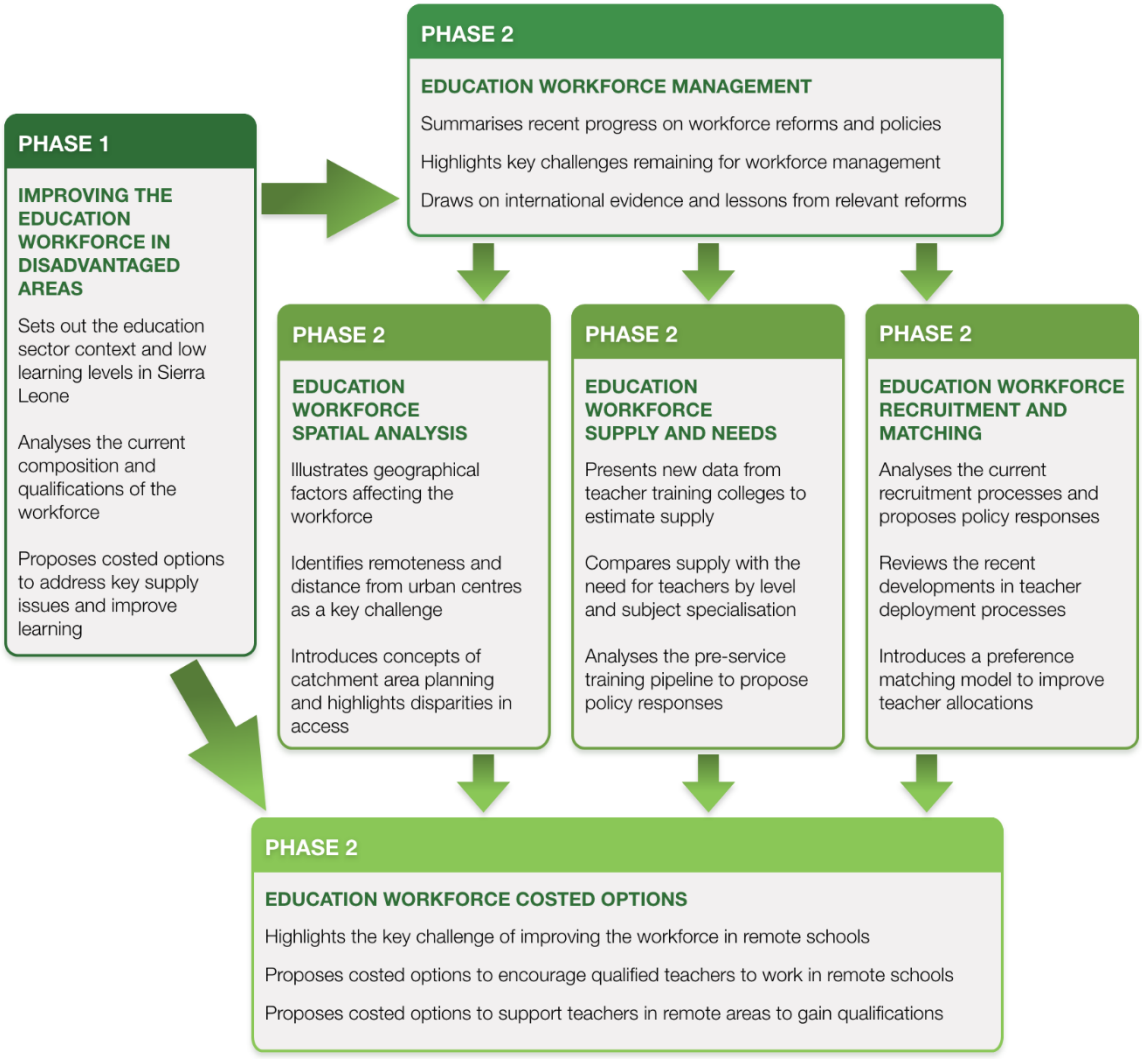



Figure 1: Education Workforce Initiative - Sierra Leone papers

# Spatial Analysis Overview

Sierra Leone has faced many challenges during its development, with rapid expansion of education access, following a long conflict, with limited resources, leading to a fragmented education system with high levels of community involvement. In practice, this has meant that a substantial proportion of teachers and education workers have been hired locally, with compromises made on their qualifications and pay. Since its formation, the Teaching Service Commission (TSC) has undertaken a number of initiatives to professionalize the education workforce.

One of the key challenges has been in trying to implement a classical, centrally administered, education workforce structure in a fragmented system characterised by many compromises. In reality the Government is not yet in a situation where they can afford to take all teachers onto the payroll, and even if they could, would have concerns over their quality. Given the disparate needs across the country, there is significant potential for spatial analysis to illustrate where challenges are greatest and highlight possible policy and programme options to address these challenges.

Spatial analysis allows for integration of considerations of geographical features and how they affect the education system in Sierra Leone. At its simplest, this is just locational, but at its more complex, it involves using distances between schools and population centres to test alternative approaches to managing the workforce. The second phase of EWI support has incorporated this lens, which is intrinsically linked to ecruitment and deployment discussions – that is, how to get equitable access to the education workforce across all schools, and introducing the concept of learning teams from the *Transforming the Education Workforce* report.

The four sections covered in this paper are:

**Section 1 Key factors affecting education workforce indicators**: a section on the differences between administrative areas in Sierra Leone, for example between Western Area and the rest of the country, whilst introducing the importance of looking within districts at more remote areas.

**Section 2 Remoteness matters**: this section highlights the remoteness categorisations to date, and where road data could be used to develop these further.

**Section 3 Harnessing the potential of learning teams**: this section illustrates the potential of a learning teams approach identified in the wider *Transforming the Education Workforce* report to combating challenges such as the shortage of subject specialists at secondary level.

**Section 4 Using spatial analysis in planning:** this section demonstrates the variation in access and enrolment in junior secondary and senior secondary education across the country and introduces how aspects of catchment area planning can help to reduce these disparities going forwards.

# 1. Key factors affecting education workforce indicators

## 1.1 Differences in the education workforce exist across Sierra Leone, but it is not as simple as just Western Area differing from the rest of the country

A common understanding is that the greatest differences in Sierra Leone are between the Western Area (i.e. Freetown and the surrounding area) and the rest of the country. We have used spatial analysis to test this, and other hypotheses, using the latest (2019) Annual School Census data.

On the surface, it is true that large differences can be seen for a number of indicators.[1] For example, Figure 2 below shows at a district level that the two districts in Western Area (circled) have better pupil-teacher ratios and shares of qualified teachers than much of the rest of the country.[2]

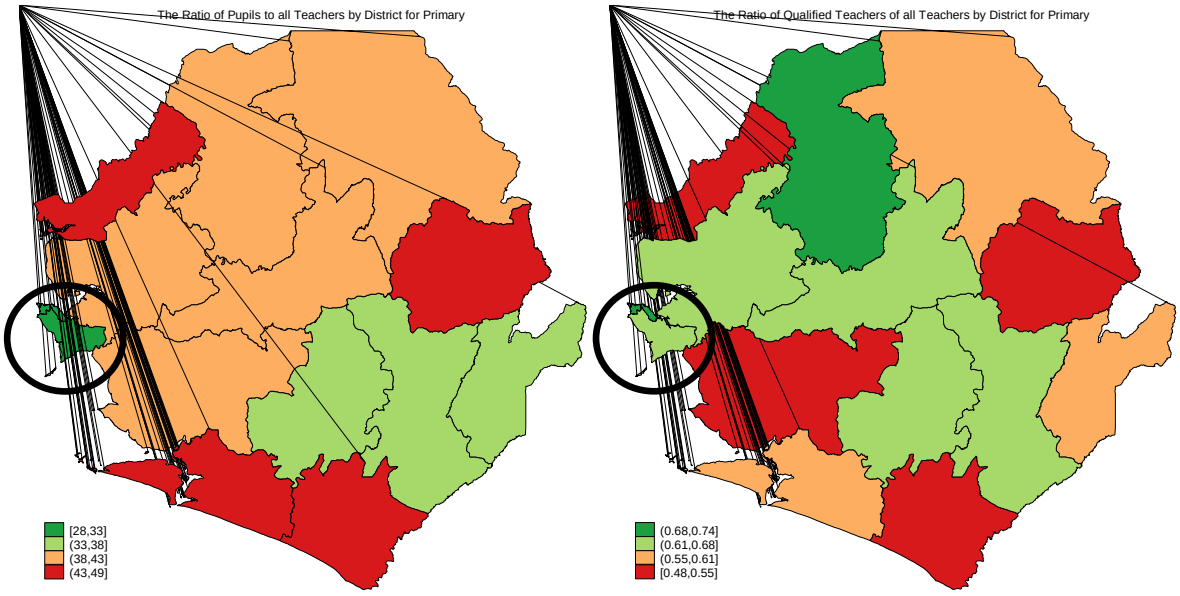



Figure 2: Education workforce indicators: pupil-teacher ratio and share of qualified teachers by district at the primary level across Sierra Leone (all schools)

[1] Key indicators considered throughout this paper include pupil-teacher ratios, pupil-qualified teacher ratios, shares of qualified teachers, core subject specialists, female teachers, and exam pass rates.
[2] Figure 2 also highlights some of the variation that can be seen across indicators and districts, which is looked at in more detail in Section 1.2.

However, there is a large influence of private schools on these headline figures. At the primary level, 22% of enrolled pupils in the Western Area are in private schools, compared with just 2% in the rest of the country.[3] While the lines between school types are more blurred in Sierra Leone than in many countries, we first detail the extent of this influence and then conduct analysis of key education indicators with and without private schools.

**Table 1: The primary school workforce in the Western Area and the rest of the country**

| Primary Level | Western Area – all schools | Western Area - excluding private schools | Rest of the country – all schools | Rest of the country – excluding private schools |
|---|---|---|---|---|
| Enrolment | 307,902 | 239,007 | 1,460,668 | 1,434,415 |
| Pupil-Teacher Ratio (PTR) | 29 | 34 | 39 | 40 |
| Pupil-Qualified Teacher Ratio (PQTR) | 41 | 43 | 64 | 65 |
| Share of teachers qualified | 71% | 78% | 62% | 62% |
| Share of female teachers | 45% | 48% | 26% | 25% |
| NPSE Pass Rate (2018) | 81% | 77% | 76% | 76% |

**Error! Reference source not found.** highlights differences between the Western Area and the rest of the country, with and without private schools. The gap in pupil-teacher ratios reduces by half when excluding private schools; while examination pass rates are close to equal once they are excluded.

**Table 2: The secondary school workforce in the Western Area and the rest of the country**

| Excluding private schools | JSS | | SSS | |
|---|---|---|---|---|
| Indicators | Western Area | Rest of the country | Western Area | Rest of the country |
| Enrolment | 103,319 | 313,976 | 103,389 | 173,432[4] |
| Pupil-Teacher Ratio (PTR) | 25 | 24 | 38 | 32 |
| Pupil-Qualified Teacher Ratio (PQTR) | 32 | 34 | 53 | 41 |
| Share of teachers qualified | 78% | 72% | 72% | 79% |
| Share of female teachers | 26% | 13% | 12% | 6% |

For secondary schools there are even smaller differences between the Western Area and the rest of the country, once we exclude the influence of private schools. Table 2[5] shows

[3] For JSS and SSS respectively, these shares are 19% and 16% of enrolled pupils in Western Area enrolled in private schools, compared with 3% and 5% in the rest of the country.

[4] Differences in access at each level of education are also considered in more detail in Section 3.

[5] Appendix A contains Tables 1 and 2 with details of additional key education indicators.

how the gaps narrow at junior secondary level, and that for senior secondary the rest of the country fares better on some key characteristics. This is influenced by the nature of senior secondary schools, which are usually located in population centres. This highlights the importance of looking in more detail within districts, not just at headline averages.

## 1.2 Differences within districts are larger than between districts

Digging deeper, it is striking in Sierra Leone how little of the variation in education workforce is explained at the district level, and that these indicators can vary hugely even within the Western Area districts. To study this in more detail, we used intra-cluster correlation analysis[6] on workforce indicators and exam pass rates. We find that a very low share (4-10%) of the variation in key indicators is across districts, and the vast majority of the variation is within districts. The results of this are shown in more detail in Appendix B.

In comparison, the intra-cluster correlation analysis finds between two and four times as much variation is evident within the next admistrative level down, at the chiefdom level. To illustrate, we show Kailahun District in more detail in Figure 3. We can see that workforce ratios in the main population centres of Kailahun District are comparable to the Western Area, while in chiefdoms farther away from these population centres, pupil-teacher ratios can reach far higher levels than any district average. These wide variations within districts are also evident across other indicators. For example, Figure 4 shows a similar pattern with pupil-to-qualified teacher ratios in junior secondary schools in Port Loko District.

[6] Intra-cluster correlation analysis tells us how much of a given indicator's variation is explained across groups (e.g. districts), and how much is explained within groups. A score of 100% would reflect all variation being between groups (if indicators were consistently different in one district compared to another), whilst a score of 0% would reflect all differences being within groups (every district across the country has specific areas where indicators were consistently different than others).

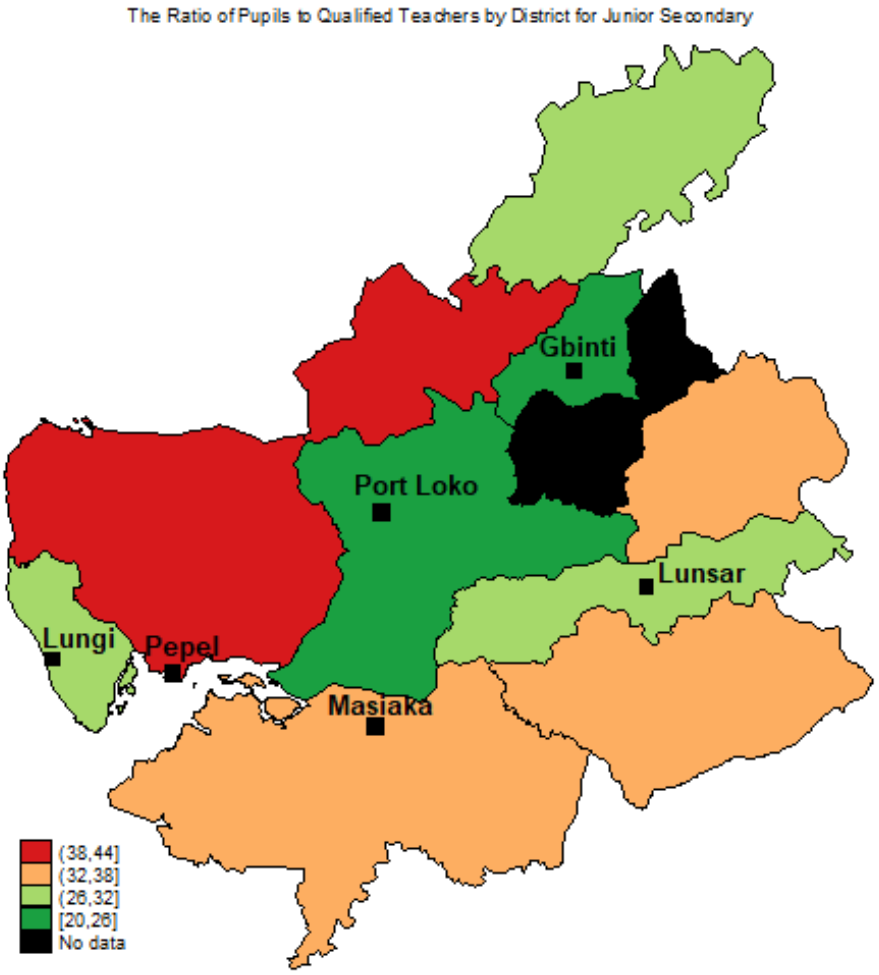



Figure 3: Kailahun District primary level pupil-teacher ratios – excluding private schools

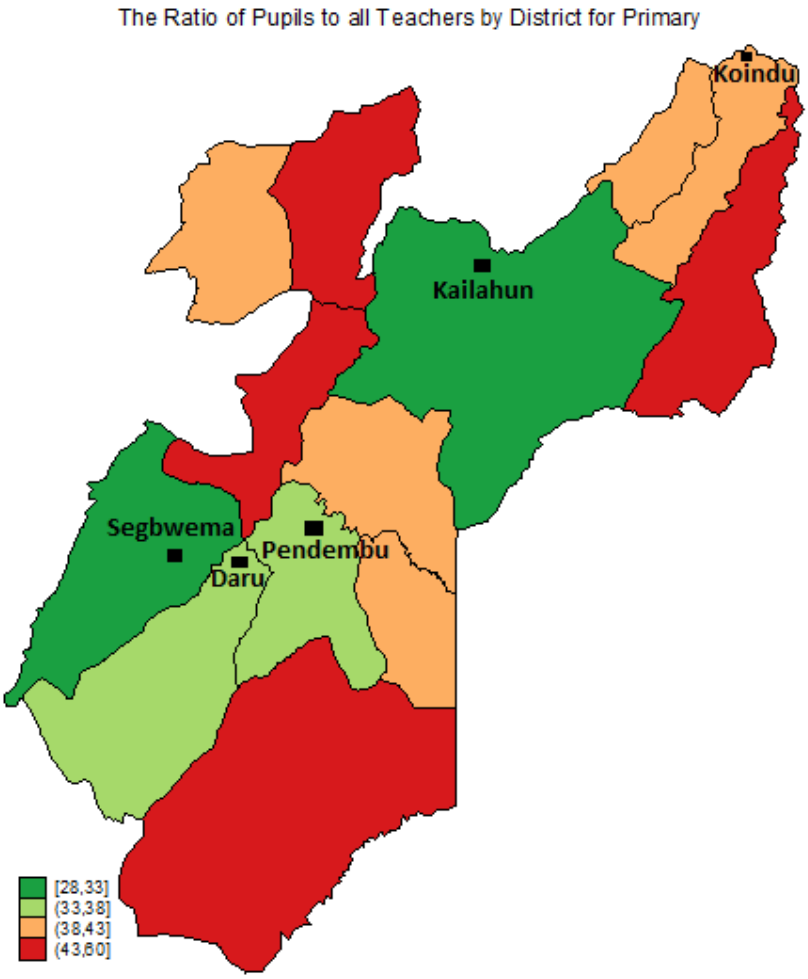



Figure 4: Port Loko District junior secondary level pupil- qualified teacher ratios – excluding private schools

This analysis supports the recent moves towards incorporating considerations of remoteness into analysis and policymaking. We investigate the remoteness measure in the new Teacher Deployment Policy and highlight how incorporating routed distances can help further improve the policy.

# 2. Remoteness matters

## 2.1 Using the new remoteness categories

Until recently, consideration of remoteness had largely only been reflected in a variable of 'accessibility' within the Annual School Census. This accessibility variable was based entirely on physical ease of access and contained four categories: 'easily accessible' (making up 64% of primary schools in 2019), 'rough terrains' (34%), 'island' (1%) and 'not accessible by road' (1%).[7]

A recent report on "Teacher Deployment and Incentives in Sierra Leone"[8] expanded this definition using focus group discussions with teachers, and proposed a new measure of remoteness, as shown in Table 3 below.

**Table 3: Defining remoteness**

| **Category A (not remote)** | Category B (moderately remote) | Category C (most remote) |
|---|---|---|
| **Within the District Headquarter town** | Outside of the District Headquarter town but has at least 3 amenities | Outside of the District Headquarter town |
| **Has at least 3 amenities** | Inside the District Headquarter town but lacks all amenities | Lacks all amenities |
| **Easily accessible all year round, including during rainy seasons** | Accessible by road all year round except during rainy seasons | Not easily accessible all year round, including during rainy seasons |

Source: Figure 5.1, p.33, Teacher Deployment and Incentives in Sierra Leone, 2019. Amenities considered are electricity, water, toilets, adequate furniture and libraries.

This measure has been taken up formally by the TSC in the December 2019 Teacher Policy[9], with a particular focus on increasing deployment of teachers to the most remote schools in Category C.

Building on the headline finding from the spatial analysis, we test these distinctions using the remoteness protocol against key indicators of schools and their workforce. In Appendix C, we present the key education workforce indicators using these categories and discuss in more detail the suitability of fit, particularly across levels of education.

[7] The ASC questionnaire provides the following information to enumerators for categorising accessibility: 'Accessibility – *Indicate ease of access to the community where the school is located*. Easily accessible: these are areas one can easily reach without difficulty either by foot or vehicle. Rough terrain: these are areas that are very difficult to reach either by foot or vehicle. Island: these are areas that are surrounded by sea [that] can only be reached by boat. Not accessible by road: These are areas that can only be accessed by foot.'

[8] The detailed methodology of this remoteness categorisation is not yet publicly available, so at this stage it is only possible to analyse based on the more limited data provided within the Remoteness Protocol dataset.

[9] See the accompanying Recruitment and Matching paper for more detail.

Overall, we find the remoteness categorisation does hold as expected for the majority of characteristics. We note though that the relationship is stronger with primary schools than secondary schools. This is affected by the lower shares of secondary schools falling into the more remote categories, albeit a weakness influenced in part by the fact they are larger, and positioned to be fed into by primary schools. Nevertheless, this does underline the potential for improving the remoteness measure, whilst also highlighting issues in coverage, with a real lack of schools in more remote areas, which we cover in more detail in Section 4.

## 2.2 Developing the remoteness protocol further using roads data

The analysis that guided the Teacher Deployment Policy also highlighted the potential to develop the remoteness measure further and revealed that focus group discussions of teachers raised the importance of the 'distance from urban towns and road network' in affecting the school location preferences of teachers.

As part of this analysis, we developed an analytical code that allowed us to estimate the distance from each school to major population centres in Sierra Leone.[10] This coding, and all tools, will be made available to the government and others, as a digital public good. Incorporating straight-line distance, and particularly routed distances along roads, can add a greater level of utility to this remoteness categorisation.

The 'routed distance' takes into account the routes that people would actually travel, for example around rivers, mountains and other topographical barriers. As an illustration, Figure 5 highlights how the straight-line distance between this school location and the nearest urban centre as 1.9km but the actual journey distance of crossing the river at the available bridge results in a routed distance of 3.8km, twice as far.

[10] We do this using the Open Street Map data on population centres and identify those classified as Town or City in their data.

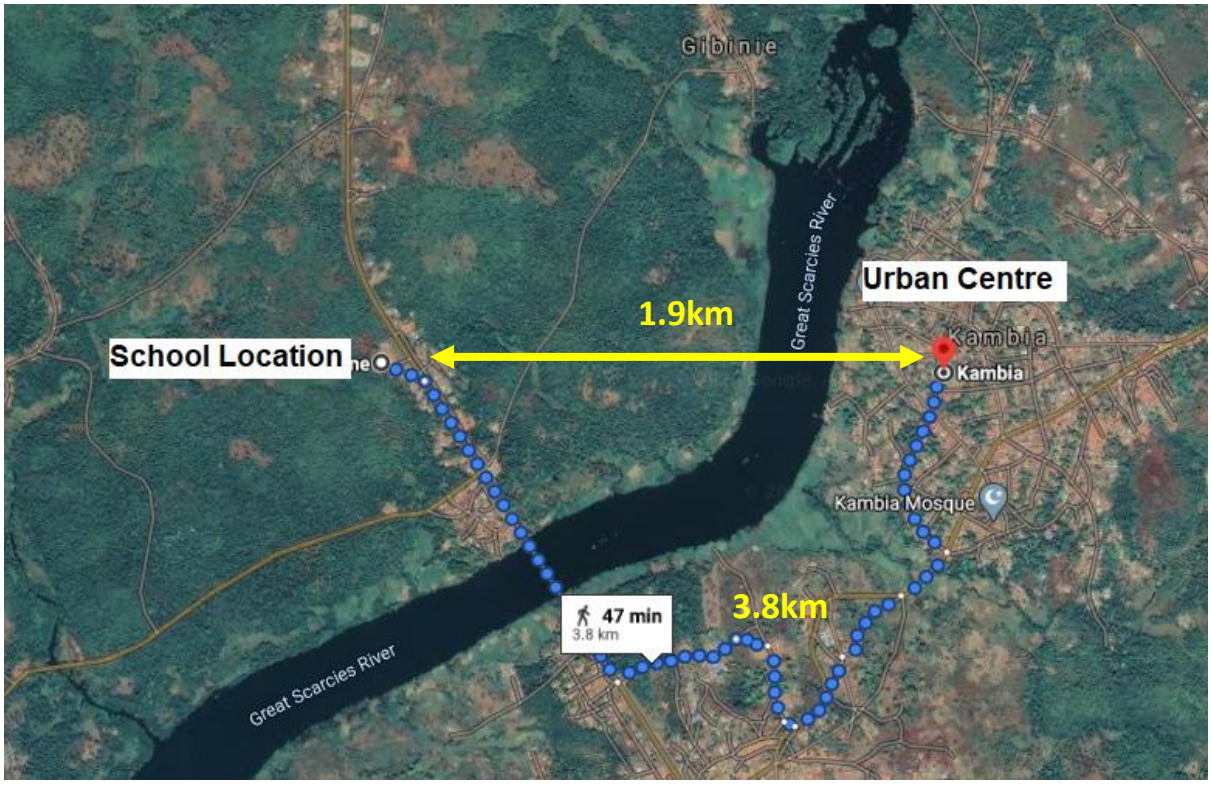



Figure 5: Example of using routed distances to urban centres compared to straight line distances

This proprietary routing technology (using Google Maps) does incur a small cost each time it is used, but as an initial output we have identified the nearest urban centre to each school by straight-line distance and the routed distance[11] that can be incorporated into remoteness analysis going forwards. We took into account distance from population centres to look into more detail at how physical access to schools impacts on the governments' ability to provide equitable access to a qualified workforce.

Looking at the workforce indicators by distance in Figure 6, there is a stark difference between schools which are within walking distance of population centres and those which are not. If we take 5km as the maximum feasible walking distance (which is approximately one hour each way) then we can see while the overall pupil-teacher ratio increases slightly, there is a huge jump in the pupil to qualified teacher ratio. This is evident at both the national level and across individual districts.

[11] Approximately 93% of schools can be routed, with the remaining 7% not appearing on Google Map searches due to issues around their GPS data coordinates.

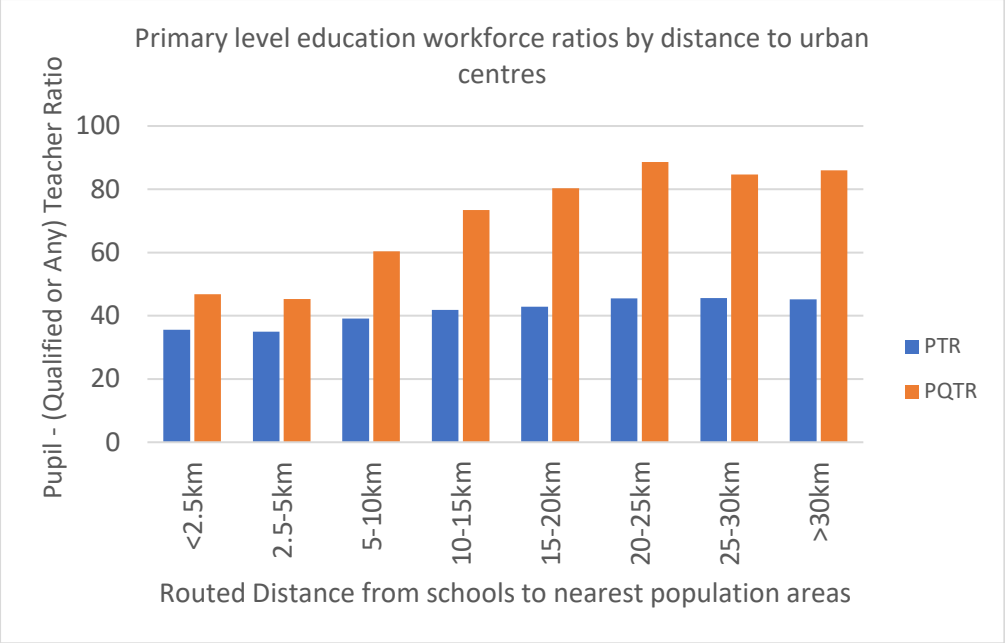



Figure 6: Education workforce ratios by distance to urban centres

This analysis supports discussions with stakeholders (including the focus group discussions for the remoteness protocol), and the practical experience of the TSC, that there are typically few difficulties in finding qualified teachers willing to work in the headquarter towns of each district but much greater challenges outside of these areas.

Looking at this in detail at the primary level in Table 4, there are stark differences in the workforce between schools less than 5km from the urban centres and those farther away. Comparing with schools between 5 to 15km away: schools less than 5km away are more likely to have qualified teachers (76% vs 56%), more female teachers (43% vs 18%) and score better in exams (80% vs 75% pass rates). It can also be seen that differences in these indicators are also larger than when comparing Western Area to the rest of the country.

**Table 4: The primary school workforce in non-private schools by distance from urban centres**

| Primary Level 2019 | Less than 5km | 5-15km | More than 15km |
|---|---|---|---|
| Pupil-Teacher Ratio (PTR) | 34 | 42 | 43 |
| Pupil-Qualified Teacher Ratio (PQTR) | 44 | 76 | 83 |
| Share of teachers qualified | 76% | 56% | 52% |
| Share of female teachers | 43% | 18% | 17% |
| NPSE Pass Rate (2018) | 80% | 75% | 71% |

At the secondary level, we see a similar pattern emerging with respect to specialist teachers, with a noticeable jump at 5km for the share of JSS and SSS schools having no specialists in any of the three core subjects (English, science and maths). This data is shown in Appendix C and this issue of lacking core subject specialists is further explored in more detail in both Section 4 and the associated Supply and Needs paper.

## 2.3 Potential policy responses

As demonstrated, remoteness matters in terms of access to a qualified workforce. One potential policy response - providing accommodation for teachers - does have some evidence of impact on teachers' morale and motivation[12] but has not been conclusively researched. We can investigate this using data on schools which already provide accommodation.

We rerun our estimates using three categories – if the school is within 5km of an urban centre; if the school is over 5km without accommodation;[13] and if the school is over 5km but with accommodation.

Surprisingly, we find little differences in the qualified-teacher-to-pupil ratio and the number of subject specialists between the latter two categories. However, this could be due to the very small number of schools having accommodation (6% of primary schools, of which, one third of these are in the radius of population centres and the majority only have accommodation for one teacher). In secondary schools, only 14% of schools have any accommodation, and of these, nearly half are in population centres – meaning only 7% of secondary schools provide accommodation outside urban centres, again mostly for only one or two teachers.

The associated Recruitment and Matching paper highlights further methods of attracting and retaining qualified staff in remote areas.

Overall, this analysis supports the move towards using remoteness in policy decisions. To do this well, it will be important to mainstream this spatial analysis within the education sector, and promote its use throughout the planning process. The Directorate of Science, Technology and Innovation (DSTI) have an important role in this, given their technical expertise – but capacity building training should also be provided to the Planning department in the Ministry and TSC to ensure uptake. Specifically, this categorisation should be incorporated into the Annual School Census data and reports, as well as TSC payroll and management data (due to its interaction with recruitment, promotion and transfer as set out in the Teacher Deployment Policy).

[12] Bennell, P., and K. Akyeampong. 2007. Teacher motivation in sub-Saharan Africa and South Asia. DFID: London

[13] Taken from the question: does your school have quarters for teachers? these are residential quarters for teacher owned by the school to keep the teachers closer to the school

# 3. Harnessing the potential of learning teams

## 3.1 Introducing the concept of learning teams

*Transforming the Education Workforce: Learning Teams for a Learning Generation*, highlighted the potential of developing learning teams to improve learning outcomes, particularly in resource-constrained contexts. Developing learning teams refers to improving collaboration within and across classrooms, schools and districts to support more effective teaching. A range of learning team configurations are put forward in the report. We focus here on one that our spatial analysis shows has potential - using specialist teachers across more than one school in order to fully maximise their impact.

There are various reasons why this type of learning-team approach is particularly suited to being implemented in Sierra Leone. The associated Supply and Need paper highlights a particular shortage of specialist subject skills in key subjects. Moreover, the spatial analysis above has highlighted that this shortage is even greater in more remote schools. Given the resource constraints of Sierra Leone, potential low-cost solutions available to mitigate these challenges is particularly welcome. Finally, the data shows that local areas have both over and undersupply of teachers at the same time – meaning it is possible to identify possible areas to pilot this.

## 3.2 Illustrating the potential of learning teams

To illustrate the potential of a learning teams' approach, we used spatial analysis to identify situations where subject specialists are being under-used in one school, while a neighbouring school is lacking the same specialist skills. We focus on the key subjects of English, Maths and Science at the junior and senior secondary levels and exclude private schools.

Across the country, the latest school census data shows that 40% of English language classes, 54% of maths classes and 42% of science classes are being taught by teachers that do not claim to be specialised *or would not be acknowledged as specialised.*[14]

[14] Note that this distinction is made because the Annual School Census allows teachers to claim that they are formally specialised in a subject, without consideration of their professional qualification or verification of such documents. As a result, many teachers that claim to be specialised in a subject are also those without a teaching qualification, or with a teaching certification. In this analysis, we focus on those only those that have HTC(P) qualifications and above and claim to be specialised. This is explained in more detail in the associated Supply and Needs paper.

Moreover, there are 557 junior and senior secondary schools without an English specialist, 817 without a maths specialist, and 789 without a science specialist. The logical question then is: for these schools, is there a school nearby with sufficient capacity to help?

We do this by identifying, for each school type:

- the closest school by distance;[15]
- the 'hours taught' per teacher, (we classify a teacher as having capacity if they teach 20 hours or less);
- a reasonable distance to travel between schools (we set at 5km assuming one hour walking is a natural barrier).

Each of these decisions has a material impact on the number of schools that can be involved and should be discussed in more detail before enacting actions based on this analysis. The analysis can also be expanded to incorporate any schools within 5km (not just the nearest); and vary the distances, for example if transport will be provided.

These criteria yields a significant number of specialist teachers who are currently being under-utilised and could potentially be shared with a nearby school in need, shown in Table 5.

**Table 3: Potential for sharing of specialist teachers across secondary schools**

| | English | Maths | Science |
|---|---|---|---|
| Underserved schools which could be reached by a shared specialist teacher | 175 | 233 | 200 |
| Share of the underserved schools which could be reached by a shared specialist teacher | 31% | 29% | 25% |
| Underserved schools which could be reached by a shared specialist teacher on government payroll | 47 | 81 | 58 |
| Share of the underserved schools which could be reached by a shared specialist teacher on government payroll | 8% | 10% | 7% |

At least one-quarter of schools that lack key subject specialists could be covered by the sharing of specialist teachers.[16] Given the conservative criteria used, this highlights the extent of the under- and over-supply of the education workforce within even small areas.

Figure 7 shows this visually across all subjects, with the host school for the learning team (where the under-utilised specialist currently works) shown in orange and the partner school[17] currently with a shortage is shown in blue.

[15] For simplicity, straight-line distance was used at this stage, but routed distances could be included.

[16] The same proportion, at least 25%, of the schools lacking in a given subject specialism could be covered by sharing teachers, when using the original subject specialism data, with any qualification.

[17] As there may potentially be more than one school within 5km, and we have currently only paired to the single-closest school, this calculation is a lower-bound estimate of the potential benefit of sharing specialist teachers with nearby schools without specialists.

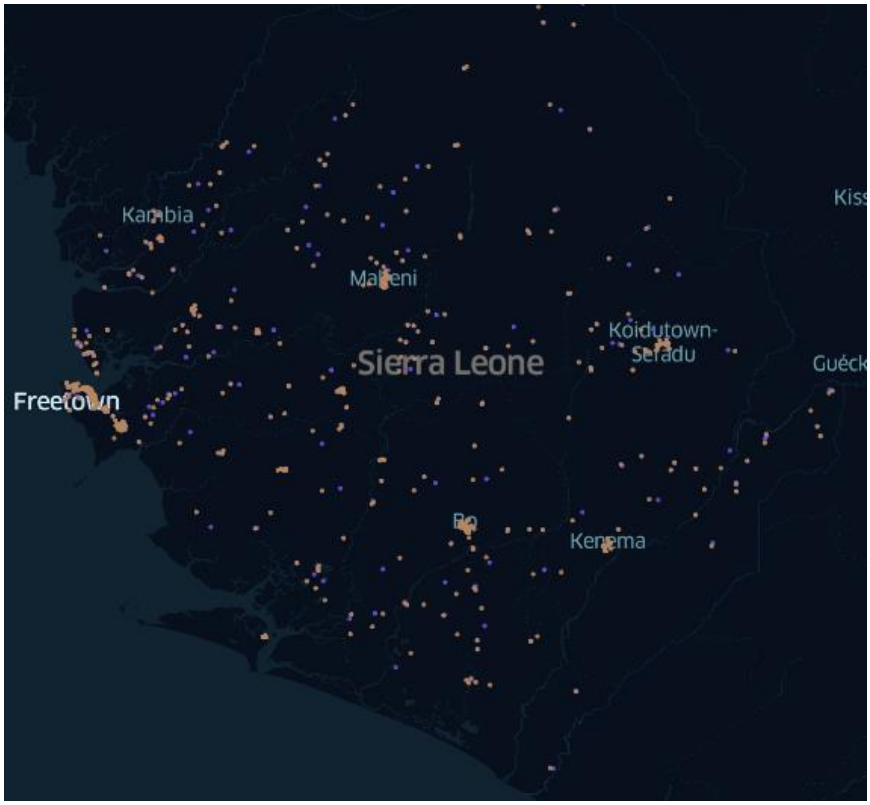



Figure 7: Schools with under-utilised specialists (orange) and in-need schools within 5km where they could be shared (blue)

This has potential for improving the efficiency of government resources, particularly if implementing this initially with the 186 'shareable teachers' on the government payroll. Compared to hiring additional teachers to cover these shortfalls in subject specialism, this would offer a far more cost-effective solution, even if incentives and/or other support[18] was offered to the teachers involved. The costs of this policy, and potential for piloting, is being considered further.

As well as the financial implications, there are also a number of practical policy considerations. Firstly, it will be important to clearly designate the management of the teacher and have monitoring procedures in place to ensure the teacher is correctly turning up at both schools. At a more localised level, teachers should be supported by ensuring coordination of the timetabling to enable them to balance classes at both schools, for example with scheduling classes at each school on alternating days or at one school in the morning, and the other school in the afternoon. Care should also be taken that teachers' other duties, such as administrative tasks, are considered and that teaching loads do take aspects, such as travel time for example, into account. Ideally this is done in a way so teachers can streamline lesson planning (i.e. not have to do planning twice, but teach the same course in both locations).

A final consideration is the need to test against civil service rules related to seniority and teaching load. Under-utilisation can often be hardwired into the contract of a very long

[18] Support in terms of transportation could be provided – either through allowances or provision of motorcycles for example. This can help to ensure that teachers (especially female teachers) can travel safely.

serving teacher, or be culturally expected. TSC should work with the teacher unions to ensure buy-in for any pilot phase.

Going forward, it is possible that technology could be incorporated across this process to potentially reduce travel, extend sharing and improve monitoring. Here the specialist can visit less frequently, and/or act as a mentor for the unqualified teachers.

All this notwithstanding, the extent of the shortage of specialists in key subjects, coupled with the potential of being able to mitigate this in up to one quarter of the schools in need illustrates the value of piloting a 'learning teams' approach.[19]

[19] It is also possible to use these methods to more accurately plan peer-to-peer learning opportunities, and clusters of school leaders. The basic argument, and tools, can help identify under-utilised members of the workforce who can aid nearby schools in many ways.

# 4. Using spatial analysis in planning

## 4.1 Enrolment at secondary varies significantly across the country

As well as helping to analyse the factors affecting the education workforce within schools currently, spatial analysis can also be useful in understanding the differences in access to schools and how this might affect education workforce indicators in the future.

In Sierra Leone, there has already been a substantial and successful drive towards universal primary enrolment, evident in gross enrolment rates (GER) exceeding 100%[20] across the country at the primary level. However, this is not the case yet for secondary education, an aspect that the removal of tuition fees as part of the Free Quality School Education (FQSE) policy aims to uncover.

In fact, as referred to briefly in Sections 1 and 2, the relatively minor differences within in-school indicators across the country may be concealing the significant differences that do still remain in secondary enrolment.

We estimate gross enrolment rates reported in the 2019 Annual School Census report to calculate the school-aged population at each level, and then divide this across the share of the total population in each district from the 2015 National Census.[21] The basis of the data used is presented in Appendix D.

This allows us to estimate approximate gross enrolment rates for each district at the junior and senior secondary levels. These are shown in Table 6 below and demonstrate significant variation across districts, between 30% and 113% at junior secondary and 10% and 114% at senior secondary level. This is far larger than the differences across any in-school indicators across districts.

[20] The gross enrolment ratio is the number of students enrolled in a given level of education, regardless of age, divided by the official school-age population corresponding to that level of education. This can exceed 100% due to the prevalence of overage students in the system.

[21] While data concerns do exist, these figures are in line with estimates based more directly from the age data reported in the 2015 census. Seeing similar estimates through two methods gives confidence that the relative picture is at least being conveyed accurately, though these figures should be updated following publication of the 2020 census data.

A concern here is also boarding schools – though we argue there is little influence from boarding schools that may reflect children studying outside of their home district. The Annual School Census reports boarding numbers as 0.2% of enrolment at primary, 0.8% at junior secondary and 1.4% at senior secondary. It also does not account for children who may stay with relatives whilst studying at secondary levels, although this also reflects a barrier to schooling even for those that are able to.

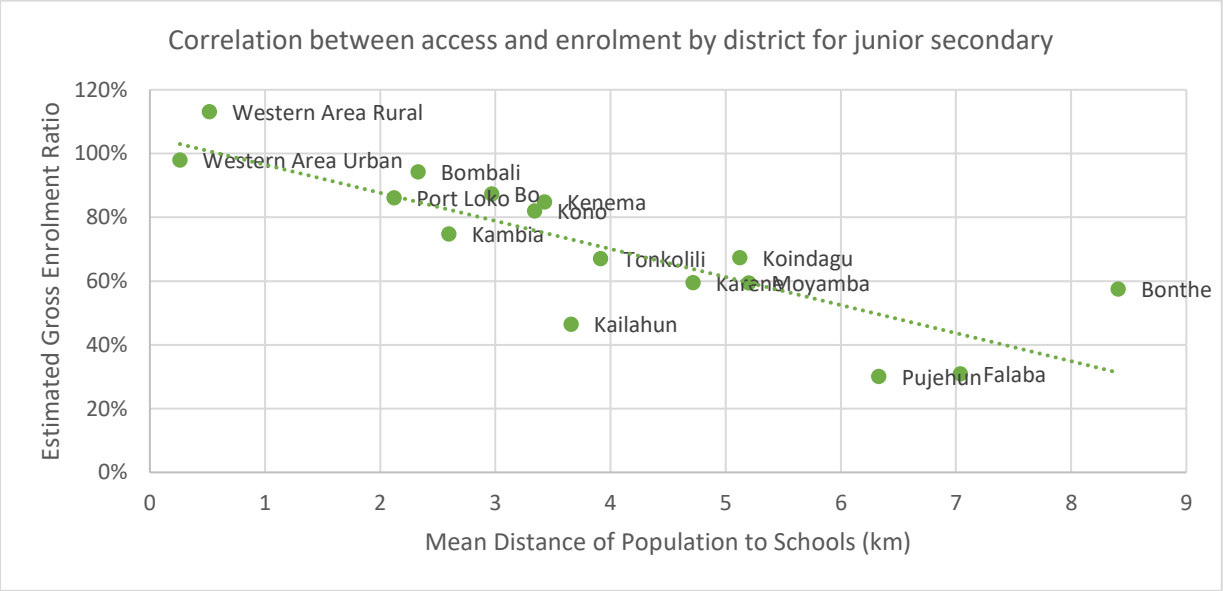
| Table 6: Current gross enrolment rates and estimated PTRs if these increased to 100% | | | | |
|---|---|---|---|---|
| District | GER Junior Secondary | JSS PTR at 100% GER | GER Senior Secondary | SSS PTR at 100% GER |
| Bo | 87% | 25 | 60% | 48 |
| Bombali | 94% | 21 | 76% | 41 |
| Bonthe | 58% | 40 | 36% | 85 |
| Falaba | 31% | 79 | 10% | 265 |
| Kailahun | 47% | 65 | 30% | 139 |
| Kambia | 75% | 32 | 40% | 73 |
| Karene | 60% | 44 | 23% | 154 |
| Kenema | 85% | 35 | 65% | 64 |
| Koinadugu | 67% | 39 | 44% | 90 |
| Kono | 82% | 36 | 49% | 73 |
| Moyamba | 59% | 37 | 22% | 80 |
| Port Loko | 86% | 24 | 45% | 57 |
| Pujehun | 30% | 106 | 10% | 261 |
| Tonkolili | 67% | 33 | 37% | 81 |
| Western Area Rural | 113% | 18 | 94% | 33 |
| Western Area Urban | 98% | 22 | 114% | 30 |
| National | 77% | 30 | 57% | 57 |

This also enables us to stress test the system against expansions in access. For example, we estimate the pupil-teacher ratios that would occur if gross enrolment increased to 100% in each district, without any increases in the education workforce. At junior secondary school level, most districts could absorb the extra students without the ratios becoming too unmanageable – the exceptions here are notably Kailahun, Falaba and Pujehun, which would have ratios of 65:1, 79:1 and 106:1, respectively. For senior secondary, expansion would be needed in almost all districts. In particular, without workforce expansion Falaba, Kailahun, Karene and Pujehun would all exceed pupil-teacher ratios of 100:1 at 100% enrolment.

# 4.2 Differences in enrolment are highly correlated with access to schools

Spatial analysis can also highlight reasons for this variation in enrolment at secondary. Using the enumerator areas of the census, which represent the geographical mid-point between 100 households, we can map out exactly where in the country people are living. This can in turn be compared to the school GIS data to illustrate the distances between where children are living and their nearest schools at each level.

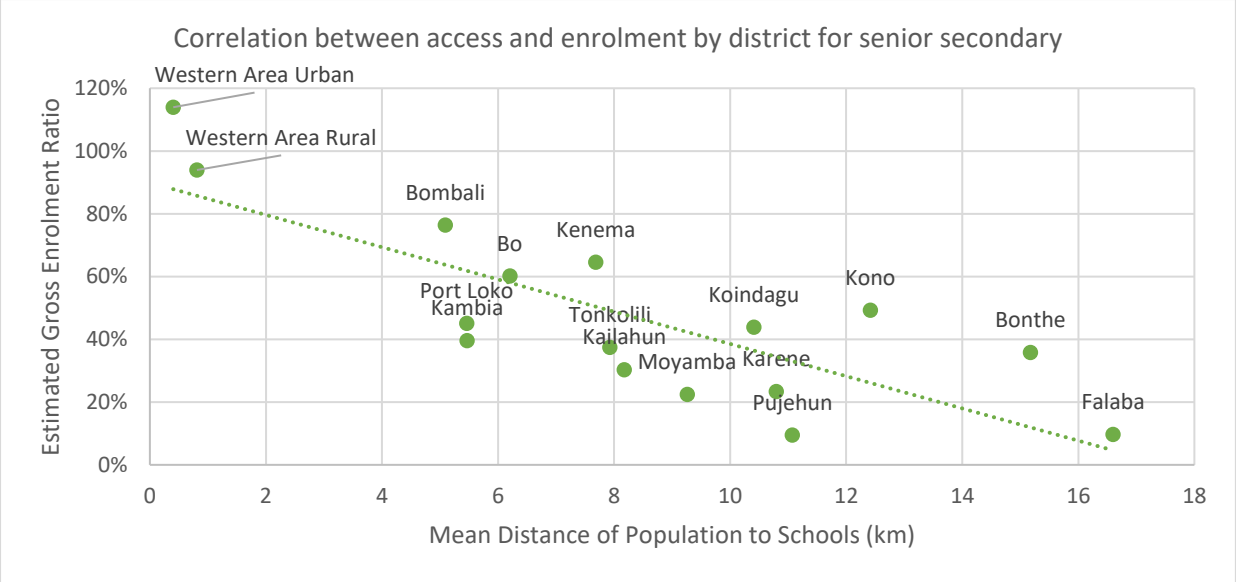
Figures 8 and 9 shows the correlation between the estimated gross enrolment rates and the average distance to schools for households. This finds a strong relationship at both the junior and senior secondary levels. This is in line with the literature[22][23] which finds that the physical location of schools is a strong determinant of access.




Figures 8: Workforce ratios by distance to urban centres for junior secondary

[22] Siddhu, Gaurav. 2011. "Who makes it to secondary school? Determinants of transition to secondary schools in rural India." International Journal of Educational Development 31(4):394–401.

[23] Moreover, in the 2018 Sierra Leone Integrated Household Survey report, 11% of those questioned in Falaba who had never attended school said that it was because it is too far.




Figures 9: Workforce ratios by distance to urban centres for senior secondary

# 4.3 Catchment area planning will be useful going forwards

While there is no global benchmark for the maximum distances that children should be expected to travel for each level of school,[24] we use 5km as a maximum distance (approximately one hour of walking). A high percentage of the population in Sierra Leone live close to a primary school, yet very far from a senior secondary school[25].

**Table 7: Approximate shares of the population by distance from the nearest schools**

| Approximate share of population… | Primary | Junior Secondary | Senior Secondary |
|---|---|---|---|
| … more than 1km away from a school | 32% | 53% | 62% |
| … more than 2km away from a school | 14% | 45% | 56% |
| … more than 5km away from a school | 1% | 24% | 47% |

[24] School Construction Strategies for Universal Primary Education in Africa, 2009, S Theunynck

[25] Note that this is likely to be a lower bound estimate, as we are assuming similar proportions of children per households, but more likely higher fertility in remote areas. The locations of these populations living more than 5km away from a school of each level is shown in Appendix E.

To further highlight the concept of catchment area planning, as well as areas of most pressing concern, we mapped a rough population density of the country, using high density population data and estimates from the census of each age group. We then, using spatial analysis, drew school catchment areas around each school – being the nearest school for any given population point. As there are 250,000 population points in the dataset, this enabled a granular picture of the school catchment. We use thessian polygons to ensure no overlaps, and highlight the broad patterns in Figure 10. We show the implied population per grade to highlight need.

At the primary level, as already evidenced Sierra Leone is relatively well served. Schools are sufficiently spread such that the cases of exceeding more than 40 per grade are relatively rare. In contrast, at the junior and senior secondary levels we find schools, particularly in the south and east, which could be serving over 500 students per grade at full enrolment. This implies a need for infrastructure investment.

While the scope of this project was not to undertake full catchment area planning, the basic tools that have been developed and shared can facilitate an understanding of the broad areas of key need. It is recommended that this work is taken forward and expanded to take into account more nuanced factors – such as the existing school sizes, number of classrooms and their potential capacity for expansion, demographic flows, enrolment flows and more. This analysis is invaluable to identify when and where construction and maintenance should be prioritised as key to ensuring an equitable and efficient flow of students through the education system, with a quality education workforce to teach them.

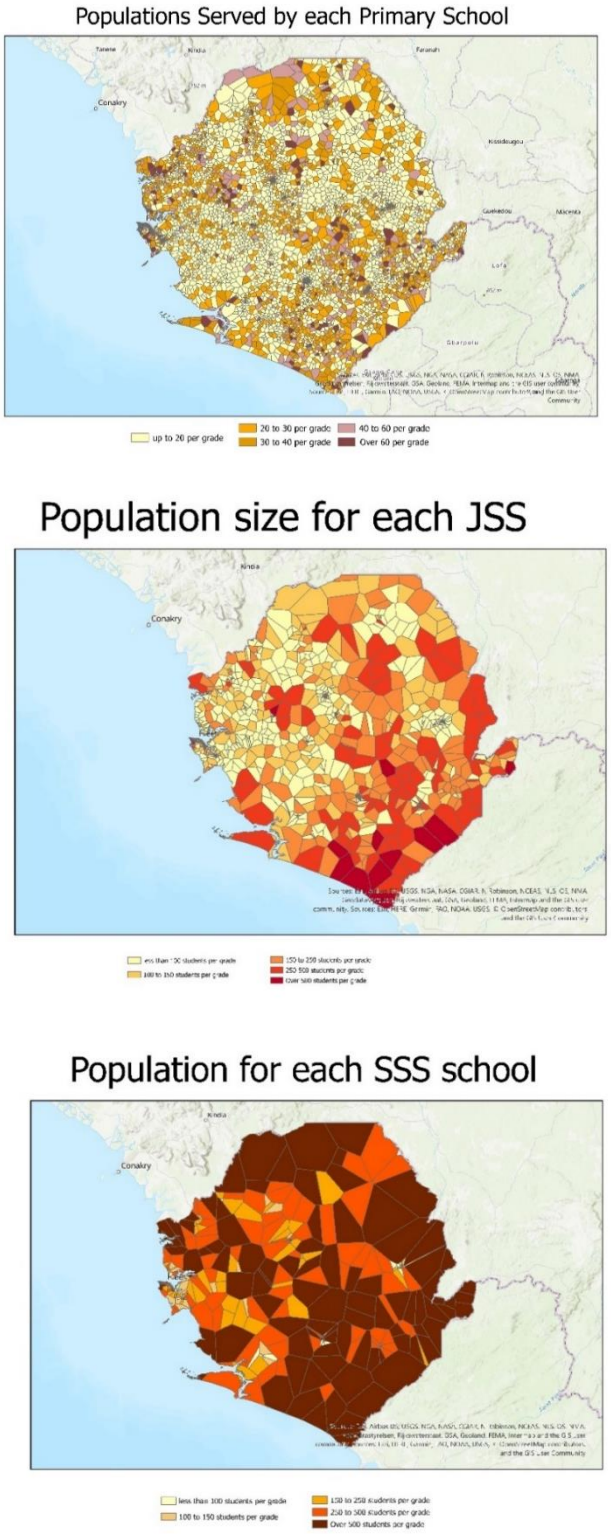



Figure 10: Catchment areas of population to nearest schools

# Appendix A

| Table 4: The primary school workforce in the Western Area and the Rest of the Country | | | | |
|---|---|---|---|---|
| Primary Level | Western Area (WA) – all schools | WA - excluding Private Schools | Rest of the Country – all schools | Rest of the Country – excluding Private Schools |
| Enrolment | 307,902 | 239,007 | 1,460,668 | 1,434,415 |
| Teachers | 10,707 | 7,125 | 37,024 | 35,869 |
| Pupil-Teacher Ratio (PTR) | 29 | 34 | 39 | 40 |
| Qualified Teachers | 7,585 | 5,538 | 22,795 | 22,075 |
| Pupil-Qualified Teacher Ratio (PQTR) | 41 | 43 | 64 | 65 |
| Share of teachers qualified | 71% | 78% | 62% | 62% |
| Share of teachers with HTC(P) and higher quals. | 27% | 29% | 12% | 12% |
| Share of female teachers | 45% | 48% | 26% | 25% |
| Share of teachers on government payroll | 36% | 53% | 39% | 41% |
| NPSE Pass Rate (2018) | 81% | 77% | 76% | 76% |
| NPSE Average Mark (2018) | 259 | 250 | 248 | 247 |

| Table 5: The secondary school workforce in the Western Area and the Rest of the Country | | | | |
|---|---|---|---|---|
| Excluding private schools | JSS | | SSS | |
| Indicators | WA | Rest of the Country | WA | Rest of the Country |
| Enrolment | 103,319 | 313,976 | 103,389 | 173,432 |
| Teachers | 4,292 | 12,905 | 2,722 | 5,389 |
| Pupil-Teacher Ratio (PTR) | 25 | 24 | 38 | 32 |
| Qualified Teachers | 3,345 | 9,330 | 1,967 | 4,277 |
| Pupil-Qualified Teacher Ratio (PQTR) | 32 | 34 | 53 | 41 |
| Share of teachers qualified | 78% | 72% | 72% | 79% |
| Share of teachers with HTC(P) and higher quals. | 69% | 56% | 69% | 76% |
| Share of female teachers | 26% | 13% | 12% | 6% |
| Share of teachers on government payroll | 46% | 37% | 46% | 50% |

# Appendix B

| Table 6: Intra Cluster Correlation Score (excluding private) | Primary PTR | Primary PQTR | NPSE[26] Pass Rate (2018) | NPSE Average Mark (2018) |
|---|---|---|---|---|
| District | 4% | 8% | 10% | 7% |
| Chiefdom | 18% | 24% | 26% | 22% |

[26] NPSE is the National Primary School Exam taken in Grade 6.

# Appendix C

| Primary 2018 | Category A Not Remote | Category B Moderately Remote | Category C Most Remote |
|---|---|---|---|
| Percentage of schools | 5% | 56% | 39% |
| Pupil-Teacher Ratio (PTR) | 24 | 29 | 32 |
| Pupil-Qualified Teacher Ratio (PQTR) | 30 | 45 | 65 |
| Share of teachers qualified | 80% | 64% | 49% |
| Share of teachers with HTC(P) and higher quals. | 27% | 16% | 9% |
| Share of female teachers | 47% | 32% | 18% |
| Share of teachers on government payroll | 51% | 43% | 35% |
| NPSE Pass Rate (2018) | 83% | 77% | 73% |
| NPSE Average Mark (2018) | 254 | 250 | 246 |

| Junior Secondary Level 2018 | Category A Not Remote | Category B Moderately Remote | Category C Most Remote |
|---|---|---|---|
| Percentage of schools | 10% | 70% | 20% |
| Enrolment | 44060 | 223874 | 42767 |
| Teachers | 2601 | 13122 | 2770 |
| Pupil-Teacher Ratio (PTR) | 17 | 17 | 15 |
| Qualified Teachers | 2001 | 9264 | 1758 |
| Pupil-Qualified Teacher Ratio (PQTR) | 22 | 24 | 24 |
| Share of teachers qualified | 77% | 71% | 63% |
| Share of teachers with HTC(S) and higher quals. | 64% | 55% | 44% |
| Share of female teachers | 19% | 16% | 9% |
| Share of teachers on government payroll | 50% | 36% | 23% |
| Share of schools lacking a key subject specialisation | 62% | 72% | 78% |

| Senior Sec Level 2018 | Category A Not Remote | Category B Moderately Remote | Category C Most Remote |
|---|---|---|---|
| Percentage of schools | 13% | 76% | 11% |
| Enrolment | 43430 | 156847 | 14159 |
| Teachers | 1668 | 6982 | 725 |
| Pupil-Teacher Ratio (PTR) | 26 | 22 | 20 |
| Qualified Teachers | 1254 | 5177 | 509 |

| | | | |
|---|---|---|---|
| Pupil-Qualified Teacher Ratio (PQTR) | 35 | 30 | 28 |
| Share of teachers qualified | 75% | 74% | 70% |
| Share of teachers with HTC(S) and higher quals. | 73% | 70% | 63% |
| Share of female teachers | 9% | 9% | 8% |
| Share of teachers on government payroll | 52% | 40% | 23% |
| Share of schools lacking a key subject specialisation | 53% | 58% | 65% |

At the primary level, the remoteness categorisation holds as would be expected across every studied characteristic. The more remote a school, the worse its pupil-teacher ratio, pupil-qualified teacher ratio, share of teacher qualifications, female teachers, teachers on government payroll and exam results.

For secondary schools, the first thing to note is the relatively lower share of schools categorised as the most remote category.

Even within this, pupil-teacher ratios are not worse in the more remote schools at secondary level. Rather, as with the broad distance measure, it seems that remote schools are substituting quantity for quality – and using their own funds to hire non-qualified teachers.

Moreover, these remoteness data highlight a particular challenge of lacking key subject specialists at secondary level (discussed in more detail in the associated Education Workforce Supply and Demand paper). This analysis also finds that the more remote a school, the greater the shortage in specialists of key subjects (English, maths and science).

| **Primary Level 2019** | **Less than 5km** | **5-15km** | **More than 15km** |
|---|---|---|---|
| Percentage of schools | 32% | 43% | 25% |
| Enrolment | 618,569 | 622,104 | 345,278 |
| Teachers | 18,407 | 14,688 | 7,951 |
| Pupil-Teacher Ratio (PTR) | 34 | 42 | 43 |
| Qualified Teachers | 14,035 | 8,209 | 4,156 |
| Pupil-Qualified Teacher Ratio (PQTR) | 44 | 76 | 83 |
| Share of teachers qualified | 76% | 56% | 52% |
| Share of teachers with HTC(P) and higher quals. | 24% | 9% | 7% |
| Share of female teachers | 43% | 18% | 17% |
| Share of teachers on government payroll | 51% | 38% | 33% |
| NPSE Pass Rate (2018) | 80% | 75% | 71% |
| NPSE Average Mark (2018) | 252 | 245 | 243 |

# Appendix D

National estimates of 6-11 year olds was calculated using the enrolment by level in 2019, and reverse calculating the school age population based on the GERs reported in 2019 Annual School Census report of 139%, 77%, 57% averaged 50:50 across genders. This was then multiplied by the share of population in each district from the national census in 2015.

| District | Share of population | Estimated 6-11 year olds | Estimated 12-14 year olds | Estimated 15-17 year olds |
|---|---|---|---|---|
| Bo | 7% | 103,497 | 47,630 | 43,738 |
| Bombali | 9% | 76,067 | 35,007 | 32,146 |
| Bonthe | 7% | 36,109 | 16,618 | 15,260 |
| Falaba | 6% | 36,932 | 16,996 | 15,607 |
| Kailahun | 3% | 94,667 | 43,566 | 40,006 |
| Kambia | 3% | 62,132 | 28,593 | 26,257 |
| Karene | 7% | 51,354 | 23,633 | 21,702 |
| Kenema | 5% | 109,686 | 50,478 | 46,353 |
| Koinadugu | 4% | 36,692 | 16,886 | 15,506 |
| Kono | 7% | 91,020 | 41,888 | 38,465 |
| Moyamba | 8% | 57,296 | 26,368 | 24,214 |
| Port Loko | 3% | 95,473 | 43,938 | 40,347 |
| Pujehun | 4% | 62,309 | 28,675 | 26,332 |
| Tonkolili | 5% | 92,437 | 42,540 | 39,064 |
| Western Area Rural | 6% | 79,900 | 36,770 | 33,766 |
| Western Area Urban | 15% | 189,910 | 87,398 | 80,256 |
| National | 100% | 1,275,481 | 586,985 | 539,019 |

| District | GER Primary | GER JSS | GER SSS |
|---|---|---|---|
| Bo | 175% | 87% | 60% |
| Bombali | 133% | 94% | 76% |
| Bonthe | 153% | 58% | 36% |
| Falaba | 109% | 31% | 10% |
| Kailahun | 101% | 47% | 30% |
| Kambia | 165% | 75% | 40% |
| Karene | 138% | 60% | 23% |
| Kenema | 151% | 85% | 65% |
| Koinadugu | 155% | 67% | 44% |
| Kono | 148% | 82% | 49% |
| Moyamba | 177% | 59% | 22% |
| Port Loko | 157% | 86% | 45% |
| Pujehun | 108% | 30% | 10% |
| Tonkolili | 150% | 67% | 37% |
| Western Area Rural | 142% | 113% | 94% |
| Western Area Urban | 102% | 98% | 114% |
| National | 139% | 77% | 57% |

| District | JSS pupil-teacher ratio | JSS student-aged population to teacher ratio | SSS pupil-teacher ratio | SSS student-aged population to teacher ratio |
|---|---|---|---|---|
| Bo | 22 | 25 | 29 | 48 |
| Bombali | 20 | 21 | 31 | 41 |
| Bonthe | 23 | 40 | 30 | 85 |
| Falaba | 24 | 79 | 26 | 265 |
| Kailahun | 30 | 65 | 42 | 139 |
| Kambia | 24 | 32 | 29 | 73 |
| Karene | 26 | 44 | 36 | 154 |
| Kenema | 30 | 35 | 41 | 64 |
| Koinadugu | 26 | 39 | 40 | 90 |
| Kono | 30 | 36 | 36 | 73 |
| Moyamba | 22 | 37 | 18 | 80 |
| Port Loko | 21 | 24 | 26 | 57 |
| Pujehun | 32 | 106 | 25 | 261 |
| Tonkolili | 22 | 33 | 30 | 81 |
| Western Area Rural | 21 | 18 | 31 | 33 |
| Western Area Urban | 22 | 22 | 34 | 30 |
| National | 23 | 30 | 32 | 57 |

# Appenidx E

Locations of populations that are more than 5km away from primary, junior secondary and senior secondary schools respectively.