Indicators and trends

Monitoring climate change adaptation

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Indicator name			Version
BT22 Landslide events affecting the road network; BT23 Road closures due to landslides			**14/03/16**
Indicator type:	**Risk/opportunity**	**Impact**	**Action**
		X	

SCCAP Theme	SCCAP Objective	CCRA risk/opportunity
Buildings and infrastructure networks	B1; B2; B3	TR2 Landslide risks on the road network

At a glance

- Climate change predictions suggest that landslide risk to the trunk road network in Scotland is likely to increase
- Landslide events affecting the trunk road network are much less frequent than flooding events
- Almost half of the recorded landslide events resulted in full road closure
- Over half of the recorded landslide events were located within very remote rural parts of Scotland which are particularly vulnerable to loss of road network connectivity

Latest Figure

Landslide incidents recorded on the trunk road network between January 2014 and March 2015	No.	%
Total number of trunk road landslide incidents	12	-
Number of these incidents resulting in road closure	5	42%
Number of these incidents located within very remote rural areas	7	58%

Trend

Why is this indicator important?

Transport is a means to an end supporting many different social and economic functions. Landslide incidents affecting road infrastructure can cause disruption to road transport with knock-on consequences for these functions, such as delaying deliveries, preventing or delaying people from accessing employment, disrupting vital healthcare services. Climate change predictions suggest that there will be an elevated risk of landslides to the trunk road network in Scotland due to the detrimental effect of increased rainfall on slope stability[1]. Tracking this indicator will show whether these predictions are realised on the ground as well as revealing any spatial patterns in the impacts.

This indicator utilises standardised trunk road incident data reported by Scotland's Trunk Road Operating Companies (TROCs), to assess landslide events affecting the road network**.** The data is managed centrally by Transport Scotland through the Integrated Road Information System (IRIS). As explained further in the limitations section, IRIS has only been fully operational since August 2014 meaning that the data presented in this section is incomplete (i.e. there may be more landslide incidents than are reported here).

Related Indicators:
BT4 Flood events affecting the trunk road network

What is happening now?

Table 1 presents current figures for landslide impacts on trunk roads.

Table 1 Trunk road network landslide incidents (January 2014 – March 2015)

Metrics	No.	%
BT22: Total number of trunk road landslide incidents	12	-
BT23: No. of trunk road landslide incidents resulting in road closure	5	42%
BT22b: No. of trunk road landslide incidents located in very remote rural areas	7	58%

Landslide incidents on the trunk road network are a much less frequent occurrence than flooding incidents. During the same period some 567 flooding incidents were reported compared to only 12 landslides (see indicator BT4). It may be the case that the prerequisite conditions for landslide are less common than the prerequisites for flooding. Furthermore, flooding can result from many sources.

[1] The total distance of road at risk will not increase indefinitely. Landslide risks to the road network require a susceptible slope above or adjacent to a road and such conditions are limited (Thornes *et al*, 2012).

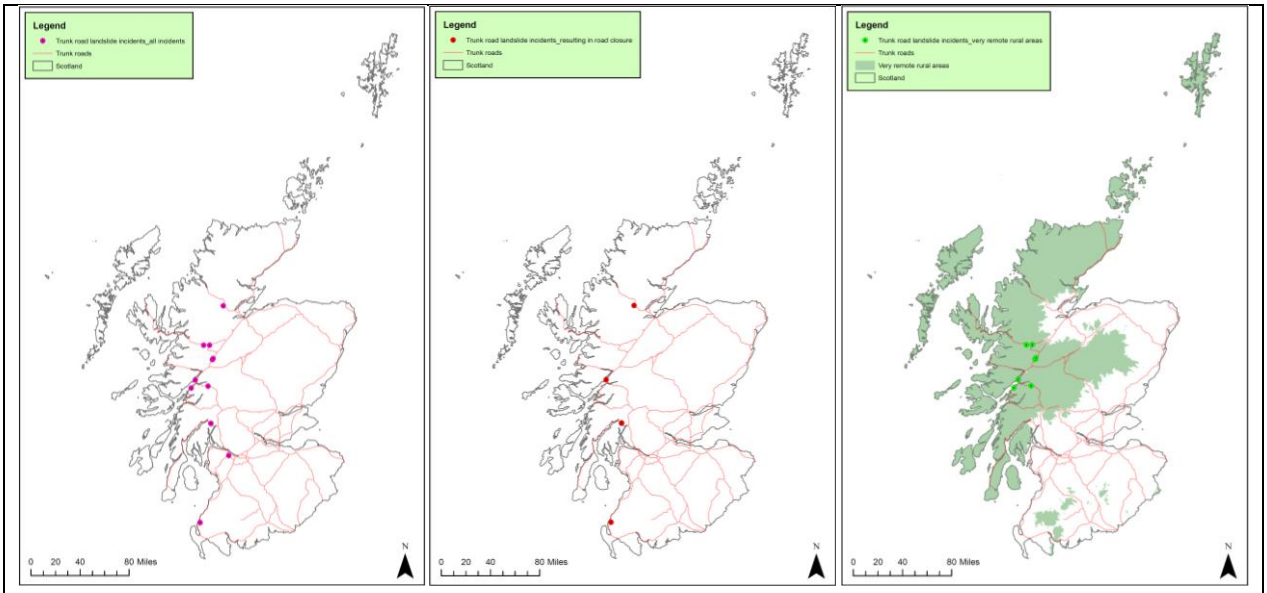

Figure 1 Location of all recorded trunk road landslide incidents (LH map); all recorded trunk road landslide incidents resulting in road closure (centre map); and all recorded trunk road landslide incidents located within very remote rural areas (RH map) between January 2014 and March 2015

Spatial data for the various landslide metrics are shown in Figure 1. Almost half of the recorded trunk road landslide incidents (5 out of 12 or 42%) recorded during the period assessed resulted in full road closure – clearly causing a more severe impact than those that do not cause a full closure.

The true cost of landslide events to the road network are often associated with the socio-economic impacts caused by the severance of access to or from relatively remote communities (Winter et al, 2013). In this context it is important to note that more than half of the recorded trunk road landslide incidents (7 of 12 or 58%) were located within very remote rural parts of Scotland.

Most of the trunk road landslide incidents recorded were in the west of the country (see Figure 1). This could, in part, be a function of the IRIS data made available by Transport Scotland as the dataset is more complete for the west of the country (see the Limitations section). However, these findings mirror the findings of an assessment of landslide hazard and risks on the Scottish road network undertaken in 2013, which found that sites with the highest hazard ranking score (greatest susceptibility) were located primarily on the west of the country (ibid). Both of these findings make sense given that landslide risks and impacts to roads require a susceptible slope above or adjacent to a road (Thornes et al, 2012). In Scotland these conditions occur most frequently on the more mountainous west side of the country.

What has happened in the past?

Historic trunk road landslide incident data is not available prior to January 2014. However, historic climate data shows how key aspects of climate (rainfall) have changed leading to impacts on biophysical systems (e.g. hydrological response of Scotland's catchments and watercourses) and ultimately changes to the scale and magnitude of relevant climate risks (e.g. landslide risks to the road network). Overall there is a clear upward trend in winter precipitation as well as increasing heavy rainfall in winter (Sniffer, 2014). Although there is no direct link between increased winter precipitation and landslide risk, the UK Climate Change Risk Assessment (CCRA) makes an assumption that increases in average winter precipitation will result in increased risk (likelihood) of landslide (Thornes et al, 2012). In this regard, it is expected that these climatic changes (Sniffer, 2014) may have

contributed to increased frequency of landslide events and associated impacts on the trunk road network. A fuller account of historic climate trends is provided in indicator BT2.

What is projected to happen in the future?

The UK Climate Change Risk Assessment (HR Wallingford et al, 2012a; Thornes et al, 2012) undertook a qualitative assessment of changes in landslide risk to road infrastructure as a result of anticipated climate changes. This included a Scotland specific assessment. The Scotland assessment considered trunk roads only and found that in all climate change (emissions) scenarios, the length of the trunk road network likely to be impacted by landslide in a year would double from the current extent by the 2080s at the latest (for medium and high emissions scenarios this increase may take place by the 2050s). This equates to an increase from 125km/year at risk today (2012) to 250km/year by 2080. It should be noted however that the total length of road at risk cannot increase indefinitely as there has to be a susceptible slope adjacent to or above the road (Thornes et al, 2012; Winter et al, 2013). Clearly these conditions are not met everywhere so there will only ever be a limited number of sites at risk of landslide.

It should be noted that any landslide incident recorded by the TROCs is likely to be of a severity such that it causes serious traffic disruption[2] (Transport Scotland, undated). In summary therefore, anticipated climate changes are likely to increase the number of landslide incidents on the trunk road network and increase traffic disruption (notwithstanding the moderating effect that preventative actions, such as increasing drainage capacity, may have).

Patterns of change

n/a

Interpretation of indicator trends

No trends identified due to lack of historical data.

Limitations

There are several key limitations to the BT22 and BT23 assessments as summarised below:

1. Transport Scotland's Integrated Road Information System (IRIS) has only been fully operational since August 2014. In particular, IRIS has been collecting TROC data for the west of the country since late 2013 but only since August 2014 for the east (Ramage, 2015). As such, the BT22/23 assessment presented here is based on incomplete data and the number of landslide events affecting the road network may be higher than that recorded. Also, it will not be possible to draw robust conclusions as to the spatial distribution of landslide events (e.g. to account for possible variations in climate and associated climate impacts between west and east Scotland).
2. Some trunk roads are not covered under IRIS as they are not managed by the TROCs (Ramage, 2015). This will also affect the accuracy of the metrics – i.e. the number of landslide events affecting the trunk road network could be higher in reality as a result.

[2] A possible exception is Transport Scotland's category 'Minor Incidents' (see Methodology section).

3. Some data recording is not mandatory for the TROCs and the consistency of data recording year-to-year may change (Ramage, 2015), especially given the somewhat qualitative nature of the trunk road incident classification system (Traffic Scotland, undated). As a result, the accuracy of the absolute figures / metrics assessed may not be consistent.

The data on number and location of landslide incidents used could be seen to paint an overly simplistic picture of landslide impacts to the trunk road network. As Winter et al (2013) point out, the real impacts of landslide related disruption are caused by the severance of access to or from relatively remote communities. Given this, it would be useful for future iterations of this indicator to access data on the duration of road closure (complete or partial) as well as annual average daily traffic (AADT) on the road link affected. This data would provide a fuller picture of the severity of disruption and the possible implications for affected communities.

References

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Winter, M.G., Harrison, M., Macgregor, F., and Shackman, L. (2013). Landslide hazard and risk assessment on the Scottish road network. *Geotechnical Engineering*, Vol.166, pp.522-539

Further information

ClimateXChange (2016) Adaptation to Climate Change: Context and Overview for Transport Infrastructure Indicators. Available online at: http://www.climatexchange.org.uk/adapting-to-climate-change/indicators-and-trends/

Acknowledgements

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Appendix One: Indicator metadata and methodology

Table 1: Indicator metadata

	Metadata
Title of the indicator	**BT22 Landslide events affecting the road network;** **BT23 Road closures due to landslides**
Indicator contact: Organisation or individual/s responsible for the indicator	ClimateXChange
Indicator data source	**Transport Scotland** – IRIS trunk roads incident data **Scottish Government** – 8 Fold Urban Rural Classification
Data link: URL for retrieving the indicator primary indicator data.	Transport Scotland: data available by arrangement only Scottish Government: http://crtb.sedsh.gov.uk/spatialDataDownload/licenc.asp

Table 2: Indicator data

	Indicator data
Temporal coverage: Start and end dates, identifying any significant data gaps.	January 2014 – March 2015
Frequency of updates: Planned or potential updates	IRIS trunk roads incident data is updated at least annually
Spatial coverage: Maximum area for which data is available	Scotland-wide
Uncertainties: Uncertainty issues arising from e.g. data collection, aggregation of data, data gaps	The consistency of trunk road incident data recording by the TROCs is uncertain
Spatial resolution: Scale/unit for which data is collected	Individual incident level
Categorical resolution: Potential for disaggregation of data into categories	By sub-national geography e.g. Local Plan District (LPD), Potentially Vulnerable Areas (PVAs), catchments
Data accessibility: Restrictions on usage, relevant terms & conditions	IRIS trunk road incident data available on request from Transport Scotland.

Table 3 Contributing data sources

Contributing data sources Data sets used to create the indicator data, the organisation responsible for them and any URLs which provide access to the data.
IRIS trunk road incident data: [not available online] SG 8 Fold Urban Rural Classification: http://crtb.sedsh.gov.uk/spatialDataDownload/licenc.asp

Table 4 Indicator methodology

Indicator methodology The methodology used to create the indicator data
Introduction to the approach This indicator presents metrics on landslide events affecting the trunk road network. The assessment is based on trunk road incident data provided by Scotland's Trunk Road Operating Companies (TROCs), in accordance with their contractual agreements (Transport Scotland, 2015). The TROCs are required to report on major, critical and minor incidents (Transport Scotland, undated). Major incidents are the most severe and minor the least (ibid). The TROCs are contractually required to collate and report a range of data on trunk road incidents as recorded by the Integrated Road Information System[3] (IRIS), which is managed by Transport Scotland (ibid). Data to be recorded by TROCs includes: 1) type of incident – e.g. flooding, landslide, road traffic collision; and 2) disruption type – includes full road closure. This and other data is used to assess specific metrics as outlined in the methodologies section below. Metric BT23 assesses the proportion of trunk road network landslide incidents resulting in road closure. Full road closure is considered to be the most severe type of landslide incident (Edmond, 2015) and this metric provides a useful proxy of trunk road network landslide event severity. Metric BT22b has also been designed to assess a specific element of risk that is of key relevance – vulnerability. The approach to defining vulnerability has been informed by the National Flood Risk Assessment (NFRA) methodology (SEPA, undated) whereby rurality is used as a proxy for road network vulnerability. The rationale for this approach is embedded in the NFRA. To this end, a separate metric has been used. In essence, roads in very remote rural areas are considered to be more vulnerable to loss of road network connectivity as there are fewer alternative routes available. Rurality has been defined with reference to the Scottish Government 8 fold urban rural classification (Scottish Government, 2014) using the very remote rural geography (see Figure 2). Very remote rural areas are defined as *"areas with a population of less than 3,000 people and a drive of over 60 minutes to a Settlement of 10,000 or more"* (Scottish Government, 2014 p.5).

[3] IRIS has only been fully operational since August 2014 – i.e. there is only a full dataset of trunk road incidents for the **whole of Scotland** from August 2014 onwards. However, IRIS data for the west of the country is available for the whole of 2014. As such, the BT22 / BT23 data presented to date is incomplete and does not capture all landslide events affecting the trunk road network (Ramage, 2015).

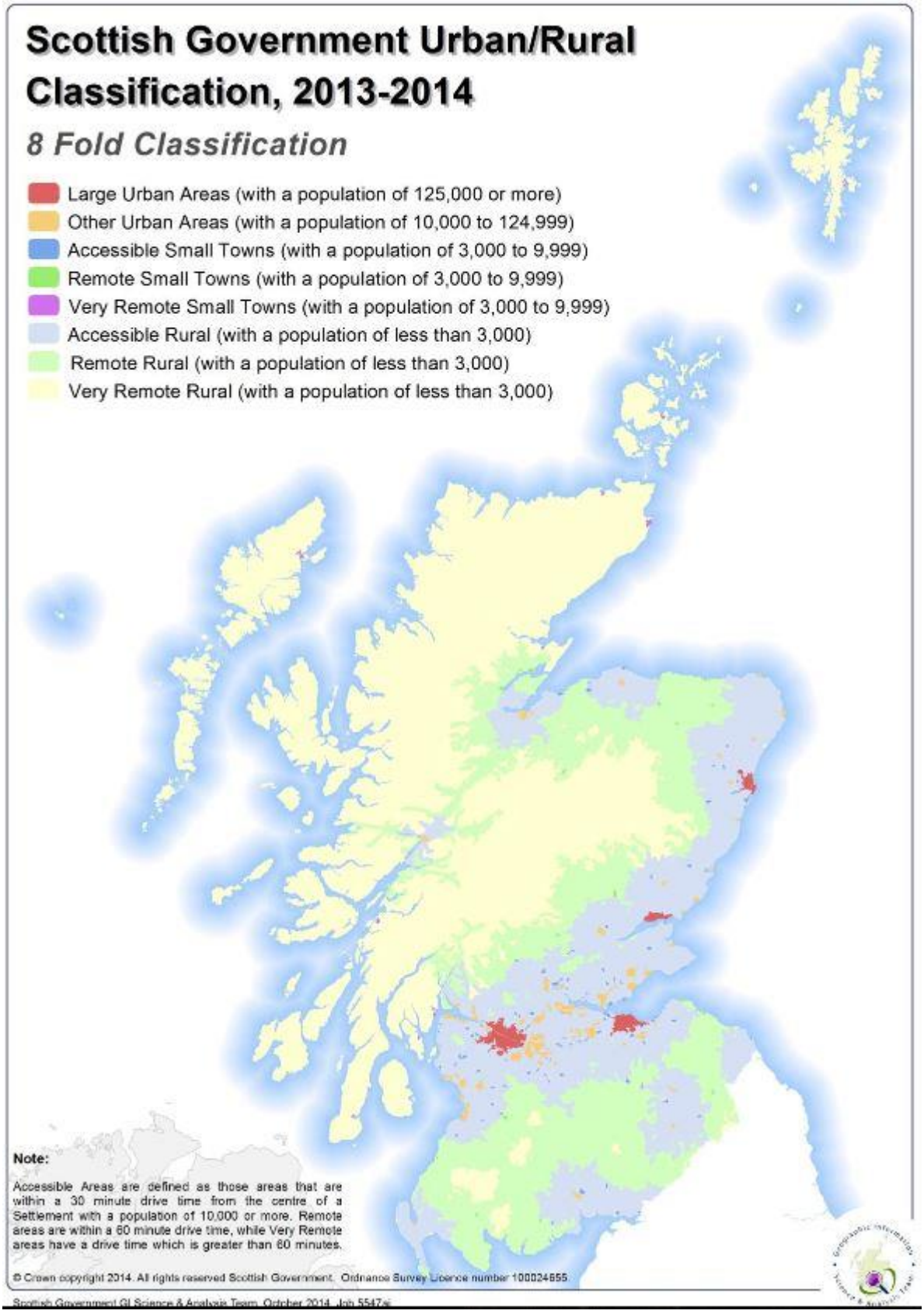

Figure 2. Scottish Government 8 fold urban rural classification 2013/2014 (Source: Scottish Government, 2014)

Box 1. Metrics assessed

- **BT22:** Total number of trunk road landslide incidents
- **BT23a:** Number (proportion) of trunk road landslide incidents resulting in road closure
- **BT22b:** Number (proportion) of trunk road landslide incidents located within very remote rural areas

Methodologies adopted in the assessment of BT22 / BT23 metrics

This section provides details of the methodology adopted to assess the BT22/23 metrics. The steps undertaken in GIS are indicated in **pale green** and steps that are undertaken in Microsoft Excel shown in **dark green**. A separate metric calculation template has been created in Microsoft Excel.

Assessment methodology for BT22 – total number of trunk road network landslide incidents	
Step	**Method**
1	Select landslide incidents only from the IRIS trunk road incidents data using the following query: "INCIDENT_T" = 'LANDSLIDE'
2	Sum the number of landslide incidents in the Assessment Step **No.1** output

BT23 – number / proportion of trunk road network landslide incidents resulting in road closure	
Step	**Method**
1	Select landslide incidents only from the IRIS trunk road incidents data using the following query: "INCIDENT_T" = 'LANDSLIDE'
2	Sum the number of landslide incidents in the Assessment Step **No.1** output
3	Select landslide incidents resulting in road closure only from the output of Assessment Step **No.1** using the following query: "DISRUPTI_1" = 'ROAD CLOSED'
4	Sum the number of landslide incidents in the Assessment Step **No.3** output
5	Divide the output of Assessment Step **No.4** by the output of Assessment Step **No.2** and multiply by 100. This produces a figure for BT23: *Number / proportion of trunk road network landslide incidents resulting in **road closure***

Assessment methodology for BT22b – number / proportion of trunk road network landslide incidents located within very remote rural parts of Scotland	
Step	**Method**
1	Select landslide incidents only from the IRIS trunk road incidents data using the following query: "INCIDENT_T" = 'LANDSLIDE'
2	Sum the number of landslide incidents in the Assessment Step **No.1** output
3	Clip the Assessment Step **No.1** output to the Scottish Government 8 fold Urban Rural Classification (SG8URC) 'very remote rural' geography
4	Sum the number of landslide incidents in the Assessment Step **No.3** output
5	Divide output of Assessment Step **No.4** by output of Assessment Step **No.2** and multiply by 100. This produces a figure for BT22b: *Number proportion of trunk road network landslide incidents located within **very remote rural** parts of Scotland*