ALIGN

Asia's Linear Infrastructure safeGuarding Nature

Spatial data resources for understanding linear infrastructure impacts on biodiversity in Asia

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Introduction

Anticipating and quantifying the effects of linear infrastructure (LI) projects on biodiversity requires spatial data. However, acquiring such data is often challenging and the available data have many limitations. Here we provide details on a variety of LI (including roads, railways, and power lines) and biodiversity data sources for Asia that may be useful in future analyses, based on CLLC's recent experience with the *Linear Infrastructure Safeguards in Asia* (LISA) project and other similar projects. We discuss (1) spatial databases of existing LI, (2) proposed LI routes from international economic development initiative planning documents, (3) already-compiled spatial databases of proposed LI routes, and (4) key spatial data layers related to biodiversity and conservation. Data from the LISA project is available for each country to download data on biodiversity core areas, proposed linear infrastructure, and country data summaries.

In some cases, existing linear infrastructure may not be adequately represented in the following datasets. Research has shown that dirt roads for extractive industries and powerlines may be especially under-represented. Additionally, proposed, or upcoming LI developers do not often make the shapefiles for proposed routes publicly available. In either of these cases, hand-digitizing in a spatial program (e.g., ArcGIS), and looking at google earth imagery or a static project proposal for a new LI project, may be required.

1. ### Linear Infrastructure

Existing Linear Infrastructure

The Global Roads Inventory Project (GRIP; Meijer et al. 2018) is a recent effort to overcome the outdatedness and spatial bias of other global roads datasets. It incorporates data from 60 road infrastructure datasets and is widely used. GRIP was first released in 2018 and we are unaware of any more recent releases. It can be downloaded at: https://datacatalog.worldbank.org/search/dataset/0040289.

Open Street Map (OSM) is a crowdsourced spatial database of roads, railways, power lines, and other infrastructure. In most densely populated areas is the most complete road and railway dataset available. It is also updated daily, which makes it particularly useful for analyses of recent infrastructure expansion. However, it may be less complete than other sources (e.g., GRIP) in some geographies due to the crowdsourced nature of the data. OSM data can be downloaded from a variety of locations, with many of them listed here: https://wiki.openstreetmap.org/wiki/Processed_data_providers.

The [Global Roads Open Access Data Set](#), Version 1 (gROADSv1) was developed under the CODATA Global Roads Data Development Task Group. The data set combines the best available roads data by country into a global roads coverage, using the UN Spatial Data Infrastructure Transport (UNSDI-T) version 2 as a common data model. Because the data are compiled from multiple sources, the dates for road network representations range from the 1980s to 2010, depending on the country, and spatial accuracy varies. National borders are provided for reference purposes only, and CIESIN and its sponsors do not take a position with regards to the representation of boundaries.

One additional resource that may be useful is a predictive mapping study by Arderne et al. (2020), who created a composite map of the global medium- and high-voltage power grids by inferring high-probability power line routes with a reported 75% accuracy. This dataset is available for viewing and downloading at: https://gridfinder.org/. It may serve as a complement to the power line data contained in OSM, which are incomplete and biased toward high-voltage transmission lines rather than lower-voltage distribution lines.

Proposed International LI Development Initiatives

Although the financers, developers, and governments associated with LI development in Asia tend not to provide the public with centralized spatial databases of proposed LI projects, information is available in other formats (primarily reports and planning documents) from many of the international economic development initiatives active in Asia. Below are sources that CLLC has found useful for compiling such information:

- The Asian Development Bank (ADB) is multilateral development bank that finances many of the largest linear infrastructure projects in Asia. A 2015 ABD brief *Regional Transport Infrastructure: Mapping Projects to Bridge South Asia and Southeast Asia* (https://www.adb.org/sites/default/files/publication/174393/regional-transport-infrastructure.pdf) includes descriptions and maps of priority road and railway development projects.
- The Association of Southeast Asian Nations is a political and economic union among Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. One of ASEAN's aims is to encourage growth in trade, industry, and agriculture, including by improving transportation facilities and power trade. The ASEAN Power Grid is a developing project to integrate member states' power systems via a network of cross-border transmission lines, and a very coarse-scale map of proposed new power lines is included in the 2019 report *Establishing Multilateral Power Trade in ASEAN* (https://iea.blob.core.windows.net/assets/37a2b2f0-bab0-47e0-a618-1a0259926b26/Establishing_Multilateral_Power_Trade_in_ASEAN.pdf). The *ASEAN Infrastructure Projects Initial Pipeline* report (https://asean.org/wp-content/uploads/2021/08/1-1.pdf) includes more detailed maps and information on selected road, railway, and power projects identified as a high priority by member states.
- The Asian Highway Network (AHN) is a collaboration between 32 Asian countries and the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) to create a continental highway network. UNESCAP has produced a coarse-scale map of the AHN available at: https://www.unescap.org/resources/asian-highway-route-map. However, many of the AHN routes are previously existing routes that will be (or have already been) upgraded and/or renamed, and thus more accurate spatial data for these existing routes under different names are likely available in existing LI databases such as OSM or GRIP.

- The Belt and Road Initiative (BRI) is the Chinese government's global infrastructure development program that includes projects across much of Asia, as well as Europe and Africa. The best available spatial data on BRI linear infrastructure projects are from a database of road and railway projects compiled for a World Bank report (Reed and Trubetskoy 2019). The spatial data from the report are available at: https://datacatalog.worldbank.org/search/dataset/0040786. Many of the projects included in this database have already been completed, and additional projects may have been added to the BRI since the database was created.
- The Central Asia Regional Economic Cooperation (CAREC) program is a collaboration between Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Tajikistan that seeks to promote economic development, including through improvements to linear infrastructure. CAREC does not have a publicly accessible spatial database of proposed LI projects, but its *Transport Strategy 2030* (https://www.adb.org/documents/carec-transport-strategy-2030) and *Railway Strategy for CAREC, 2017-2030* (https://www.adb.org/documents/railway-strategy-carec-2017-2030) documents include coarse-scale maps of proposed road and railway corridors.
- The Central Asia-South Asia Power Project (CASA-1000) is a project to construct high-voltage transmission lines that will link Kyrgyzstan, Tajikistan, Afghanistan, and Pakistan, allowing Central Asian countries with surplus hydroelectric power to supply South Asian countries with electricity deficits. The best publicly available spatial data is a coarse-scale, geographically simplified map on the CASA-1000 website (https://www.casa-1000.org/).
- Great Mekong Subregion Economic Cooperation Program (GMS) is a collaboration among the countries of the Mekong River Basin (Cambodia, China, Laos, Myanmar, Thailand, and Vietnam), funded by the Asian Development bank and other donors, that supports development projects in transport, energy, and other sectors. Spatial data (in shapefile format) on existing and proposed routes of the GMS regional power network (https://www.greatermekong.org/gms-regional-power-trade-illustration) and the GMS railway network (https://www.greatermekong.org/gms-railways-status) are both publicly available, although routes are only approximate.
- The Asian Super Grid/Gobitec project seeks to connect locations of high energy demand in Northeast Asia (e.g., Seoul, Tokyo, Shanghai) with renewable energy sources in the Gobi Desert via a network of high-voltage transmission lines. The project does not appear to have progressed since 2014, and only a rough map of proposed transmission line routes is available (https://www.energycharter.org/fileadmin/DocumentsMedia/Thematic/Gobitec_and_the_Asian_Supergrid_2014_en.pdf).
- The South Asia Subregional Economic Cooperation (SASEC) program is a collaboration between Bangladesh, Bhutan, India, Maldives, Myanmar, Nepal, and Sri Lanka to increase intraregional trade and develop connectivity with Southeast Asia. SASEC does not have a publicly accessible spatial database of proposed LI projects, but its *Operational Plan 2016-2025* (https://www.adb.org/sites/default/files/institutional-document/551061/sasec-operational-plan-2016-2025-update.pdf) includes coarse-scale maps of proposed road, railway, and power line corridors.
- The Trans-Asian Railway Network (TAR) is a collaboration between 17 Asian countries and UNESCAP to create a continental highway network. UNESCAP has produced a coarse-scale map of the TAR available at: https://www.unescap.org/resources/trans-asian-railway-network-map. However, some parts of the TAR consist of previously existing railway routes that will be (or have already been) upgraded or renamed, and thus more accurate spatial data for these existing routes under different names are likely available in existing LI databases such as OSM.

LI Databases

Several non-governmental organizations have developed their own databases of proposed and/or recent LI projects in Asia that may serve as a useful starting point for spatial analyses, including:

- CLLC, as part of the USAID-funded Linear Safeguards for Infrastructure in Asia project, compiled a spatial database including proposed routes from the all the international economic development initiative sources in the previous section. That database is available in shapefile format from CLLC upon request. However, the limitations of the database must be emphasized. Because most of the routes included in the database were digitized from coarse-scale maps, there is potentially large spatial error in route locations, perhaps on the order of 50+ km in some cases. In addition, the most recent planning documents we could find were sometimes several years old, and we included these projects in the database but encourage users to verify that they are still current if possible. The CLLC database was released in 2021 and there are no plans to update it.
- The Stimson Center maintains an interactive online database of infrastructure projects in the Mekong River Basin called the Mekong Infrastructure Tracker (https://www.stimson.org/project/mekong-infrastructure/). Many of the road, railway, and power line projects overlap with those in CLLC's database, but the Mekong Infrastructure Tracker also includes waterways and several types of non-linear infrastructure (power generating facilities, industrial spaces, etc.). This database is actively maintained, although the frequency of updates is unknown.
- The Center for Strategic and International Studies created the Reconnecting Asia Project Database (https://reconasia.csis.org/reconnecting-asia-map/), which includes over 14,000 infrastructure projects (power plants, roads, railways, ports, intermodal, power lines, and pipelines) constructed across Eurasia since 2006. However, the database is non-spatial and is no longer being maintained as of June 2022, so it is a better source of information on recent LI projects than future LI projects.
- The Global Infrastructure Impact Viewer is a tool for visualizing the first global database of planned road and railway infrastructure, and the risks and benefits it may pose to people and the natural world.

2. **Biodiversity Data**

The most basic measure of biodiversity is species richness (the number of species present at a location). One widely used global species richness dataset was developed by Jenkins et al. (2013) by overlaying species range maps from the IUCN. This moderate-resolution (10x10 km^2) dataset is available for three taxonomic groups (mammals, birds, and amphibians), with separate layers available within each of these taxa for threatened species and small-ranged species. Data were updated in 2017 and are available at: https://biodiversitymapping.org/.

Several biodiversity indices have been developed that seek to measure ecological intactness or integrity on the basis of the fraction of remaining biodiversity, the influence of human activities, or the amount and spatial distribution of habitat. The following datasets may be especially useful for assessing potential biodiversity impacts of LI projects because they have global coverage, fine spatial resolution (grid cells ≤ 1 km^2) and were recently released.

- Beyer et al.'s (2020) Ecoregion Intactness index is a measure of habitat intactness that accounts for the combined impact of habitat loss, fragmentation, and degradation arising from anthropogenic disturbance. Data are available at: https://espace.library.uq.edu.au/view/UQ:f51cace.
- Kennedy et al.'s (2019) Global Human Modification index measures the proportion of the landscape modified by modeling the physical extents of 13 anthropogenic stressors and their estimated impacts. Data are available at: https://figshare.com/articles/dataset/Global_Human_Modification/7283087.
- Newbold et al.'s (2016) Biodiversity Intactness index is based on the average abundance of originally present species across a broad range of species, relative to abundance in undisturbed habitat. Data are available at: https://data.nhm.ac.uk/dataset/global-map-of-the-biodiversity-intactness-index-from-newbold-et-al-2016-science.
- The Global Forest Watch program provides annual, high-resolution maps of forest cover loss and gain, and has also mapped Intact Forest Landscapes - unbroken expanses of natural ecosystems within the zone of forest extent that show no signs of significant human activity and are large enough that all native biodiversity could be maintained (Potapov et al. 2017). Data are available at: https://data.globalforestwatch.org/.
- Movebank is a free, online database of animal tracking data hosted by the Max Planck Institute of Animal Behavior. They host animal tracking data to assist managers analyze and archive their data.

Several other datasets related to protected areas, or areas that may warrant future protection, may also be relevant for considering LI impacts to biodiversity.

- The World Database on Protected Areas (WDPA), maintained by the United Nations Environment Programme's World Conservation Monitoring Centre, is the most authoritative and comprehensive global database of protected areas. It is frequently updated and has recently begun incorporating Other Effective Area-Based Conservation Measures – areas that lack formal protection status but are managed to achieve conservation outcomes. The WDPA is available for download at: www.protectedplanet.net.
- BirdLife International maintains a global database of Key Biodiversity Areas, which are sites that are globally important for conservation based on threatened biodiversity, geographically restricted biodiversity, ecological integrity, biological processes, or irreplaceability. The database is frequently updated and is available upon request at: https://www.keybiodiversityareas.org/kba-data/request.
- The World Bank Group's International Finance Corporation developed a 1-km^2-resolution map of critical habitat as defined by its Performance Standard 6. Critical habitat is based on five criteria that address habitat of significant importance to threatened, endemic, congregatory and migratory species, threatened or unique ecosystems, and key evolutionary processes. The dataset is used by businesses as a screening tool for siting development projects in a manner that minimizes biodiversity loss. The critical habitat layer is described in detail in Brauneder et al. (2018) and is available for download at: https://data.unep-wcmc.org/datasets/44.

3. Other relevant datasets

In addition to linear infrastructure and biological diversity, the ALIGN project considers ecosystem services, climate resilience, and Indigenous Peoples and Local Communities (IPLCs). Below are some spatial datasets that may be useful for spatial research, planning, and ecological connectivity efforts that are informed in a holistic way.

Ecosystem Services
- Ecosystem Services Partnership (ESP) Data Portal: The ESP Data Portal provides access to various ecosystem services datasets from around the world, including Asia. It includes data on provisioning services (e.g., food, water), regulating services (e.g., climate regulation, water purification), supporting services (e.g., habitat provision), and cultural services (e.g., recreation, cultural heritage) across different spatial scales. To use the ESVD, you can register for a free account. https://www.esvd.net/

Climate Resilience
- IMF (International Monetary Fund) has developed a **Climate Change Dashboard** to provide information on the economic and financial implications of climate change for countries around the world. The dashboard serves as a tool to assess and visualize the economic risks and vulnerabilities that countries may face due to climate change and the transition to a low-carbon economy. https://climatedata.imf.org/pages/access-data

Indigenous Peoples and Local Communities (IPLC)
- **LandMark** is a global platform that maps and provides information on Indigenous and Community Lands. While its coverage is global, it includes data on IPLC territories in Asia as well. https://www.landmarkmap.org/data/

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