Technical Assistance Consultant's Report

Project Number: 47184-003
December 2015

Regional: Geomapping of ADB's Projects
(Financed by the Technical Assistance Special Fund)

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For Asian Development Bank

Asian Development Bank

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I. EXECUTIVE SUMMARY

1. The objective of **TA-8713 REG: Geomapping of ADB's Projects (47184-003)** was to enhance the Asian Development Bank's (ADB) transparency and the availability of its operational data by developing a mapping platform (hereafter referred to as the "geomapping application") that visualizes the geographic location of ADB projects in a user-friendly and easy-to-understand matter. One of the key aims behind developing this tool is to make the tool available to the public through ADB's external website (http://www.adb.org) so that this geocoded information can be used as a resource to better visualize and understand ADB's project portfolio in the Asia-Pacific region. This TA also targeted to identify the necessary resources and governance structure for the sustainability of the geomapping application.

2. Prior to this TA, Development Gateway worked with ADB under **TA 8603 REG: Geocoding of ADB's Projects (47184-002)** to successfully integrate geocoding as part of ADB's project and portfolio management workflow. Over the course of February – December 2014, Development Gateway worked in conjunction with ADB to geocode the ongoing portfolio of ADB projects and to develop and integrate a geocoding tool within ADB's project management workflow, which is now live and in use in ADB's eOperations system. This tool plays an integral part in sustaining geocoding as core functionality within ADB's project management processes and ties into the overall sustainability of the geomapping application since it allows for the addition and modification of ADB project locations.

3. Under this TA, Development Gateway (DG) successfully:
   a. Held a requirements gathering mission 2 - 8 December 2014 in ADB Headquarters, Manila, the Philippines to collect the necessary requirements and specifications for the geomapping application
   b. Geocoded ADB-financed operations approved from April to October 2014, including TAs and non-sovereign projects
   c. Developed a geomapping application that suits ADB needs, based off of several rounds of feedback with ADB and user testing
   d. Maintained both the geocoding widget and geomapping application, as well as the hosting of the geomapping application, through 31 December 2015
   e. Discussed and provided recommendations to ADB on the hosting of the geomapping application for both the upcoming year, as well as the longer term, via several reports and checklists

4. The geomapping application created under this TA was developed under close coordination with ADB's Strategy and Policy Department (SPD) as well as ADB's Department of External Relations (DER). Development Gateway developed and iterated on the various test demos that were sent to ADB for feedback and approval, ensuring that the geomapping application was developed in a manner that best suited ADB's needs. ADB's Office of Information Systems and Technology (OIST) was also kept appraised throughout the course of the TA, particularly with regards to discussions on the future hosting and maintenance of the geomapping application.

II. BACKGROUND

5. This TA continued and expanded upon the existing achievements ADB has undertaken in institutionalizing geocoding within the Bank's project management workflow, via TA-8603 REG. By having the process of geocoding in place for project officers to record and modify project locations for ADB-financed operations, ADB is committed to showcasing this detailed information via its public-facing website: www.adb.org. ADB's commitment to sharing its geocoded information is also reflected in how ADB has worked to include information in its International Aid Transparency (IATI) reporting, which has been internationally recognized via ADB's high performance in the Aid Transparency Index.

6. Other multilateral banks and international organizations such as the World Bank, the African Development Bank, Inter-American Development Bank, UNDP, and DfID – have worked to incorporate geospatial data onto their websites; with lessons learned from these organizations regarding their experiences of opening up their location data, ADB was well-poised to make use of these experiences to lead the next wave of innovations for Development Partners to visualize project activities across beneficiary countries.

7. The achieved deliverables under the previous TA have thus far not only helped to further support ADB's internal and technical goals in institutionalizing geocoding within the ADB, but have also helped to further the strategic importance of ADB's work in the global aid and transparency community. The geomapping application will also contribute to the messaging, as well as practical implications, of ADB's commitment to using geospatial data and analysis as a pivotal tool in ADB's workflows and visualizations.

8. A requirements gathering mission, which took place from 2 – 8 December 2014 at ADB Headquarters, Manila, the Philippines, detailed: the (i) functional design of the mapping platform, (ii) technical design and requirements, and (iii) potential integration of the mapping platform with ADB's existing IT infrastructure (including adb.org website). This information was presented to ADB in a requirements gathering / inception report, which was iterated on during the course of the TA to provide further details regarding the various, potential hosting arrangements for the geomapping application.

9. The following list summarizes the general features of the geomapping application:

- Easy-to-use interface and acceptable performance for use in low-bandwidth environments in ADB's developing member countries (DMCs);
- Compatibility with a variety of browsers including Internet Explorer (9 and above), Google Chrome, Firefox and Safari;
- Responsive web design;
- A filters feature for customization of the information displayed on the map;
    - Ability to export the map data and share the map (with pre-selected filters active to display selected information); and

- Thematic maps of socioeconomic indicators and data, such as subnational population density, that may be overlaid on the base map.

10. The geomapping application developed under this TA was built to expand upon ADB's existing processes of transparency; the application uses ADB's IATI files, which are publicly available online, as the data source that populates the geomapping application. This is indeed an innovative way for ADB to use its IATI information – an internationally recognized standard of reporting aid information – via its own internal processes and could spearhead similar initiatives among other Development Partners, as a way to ensure consistency and compatibility of donor-reported location data, particularly for cross-donor analyses.

11. In developing the geomapping application, the options that provided the best balance of application performance, ease of implementation, and maintainability were sought. From the IT side, open-source products have been utilized (for example, Esri's web-based integration with Leaflet for the geomapping application's basemaps) as a means to ensure fewer internal IT infrastructure dependencies as well as to adhere to international best practice regarding the increased usage of open source applications and procedures.

12. Having fully developed the geomapping application, ADB and Development Gateway will work in early 2016 to integrate the geomapping application onto ADB's website, with support from ADB's Department of External Relations (DER) team, to publicly launch the application for external use.

13. This report will go into depth regarding the outputs and outcomes that have come about as part of this TA. This report will also recommend next steps for ADB now that this TA is complete.

III. OUTPUTS AND OUTCOMES

14. The following lists the deliverables under this TA, as well as the associated status for each deliverable:

- A requirements gathering mission during 2 - 8 December 2014 to collect the necessary requirements and specifications for the geomapping application.
    - **Completed.**
- A requirements report to be sent to ADB after the completion of the mission, by 19 December 2014, for review and finalization of the design and requirements for the geomapping application.
    - **Completed.**
- ADB-financed operations approved from April to October 2014, including TAs and nonsovereign projects, will be geocoded and submitted to ADB.
    - **Completed.**
- A final version of the geomapping application to be completed by 31 December 2015.

    - **Completed.**
- Ongoing maintenance of both the geocoding widget and geomapping application, as well as the hosting of the geomapping application until 31 December 2015.
    - **DG has maintained both applications, as well as hosted the geomapping application, through 31 December 2015.**

15. The following sections describe in-depth the outcomes associated with each of the TA's outputs.

16. **Requirements report.** The Development Gateway team submitted a requirements report that was used as the basis for ADB's approval of the geomapping application features prior to the commencement of the application's development. Development Gateway and ADB had several iterations of the report to ensure that the report encompassed all of ADB's information needs so that ADB could effectively make decisions on the necessary ADB action points.

17. **Geocoding of ADB-financed operations.** During the current TA, ADB-financed operations approved from April to October 2014, including TAs and nonsovereign projects, were geocoded and submitted to ADB for inclusion in ADB's IATI release. During the prior TA, ADB's loan and grant operations, approved and either closed in 2013 or not closed as of April 2014, financed by the Ordinary Capital Resources (OCR) and the Special Funds, including the Asian Development Fund (ADF) were geocoded by DG. TA projects approved between January 2013 and April 2014 were also geocoded. Annex 1 describes the geocoding process in detail.

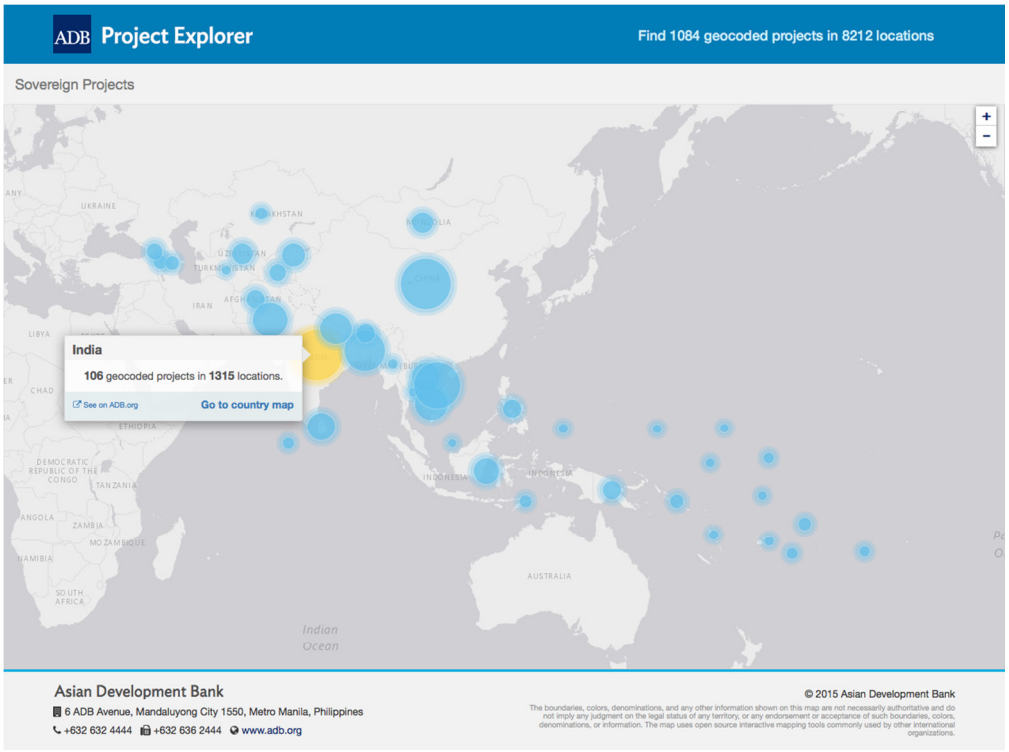
18. All of this geocoded information is available in the geomapping application, as it has been reported to ADB's IATI files, which are used as the basis of the data populating the geomapping application.

19. However, starting from 2015, project officers work to ensure that all new projects are geocoded via the geocoding widget in eOperations. The structure of the geocoded data provided in eOperations is also compatible with the current version of the international standard set by IATI and will thus be incorporated in the geomapping application with each new ADB IATI release.

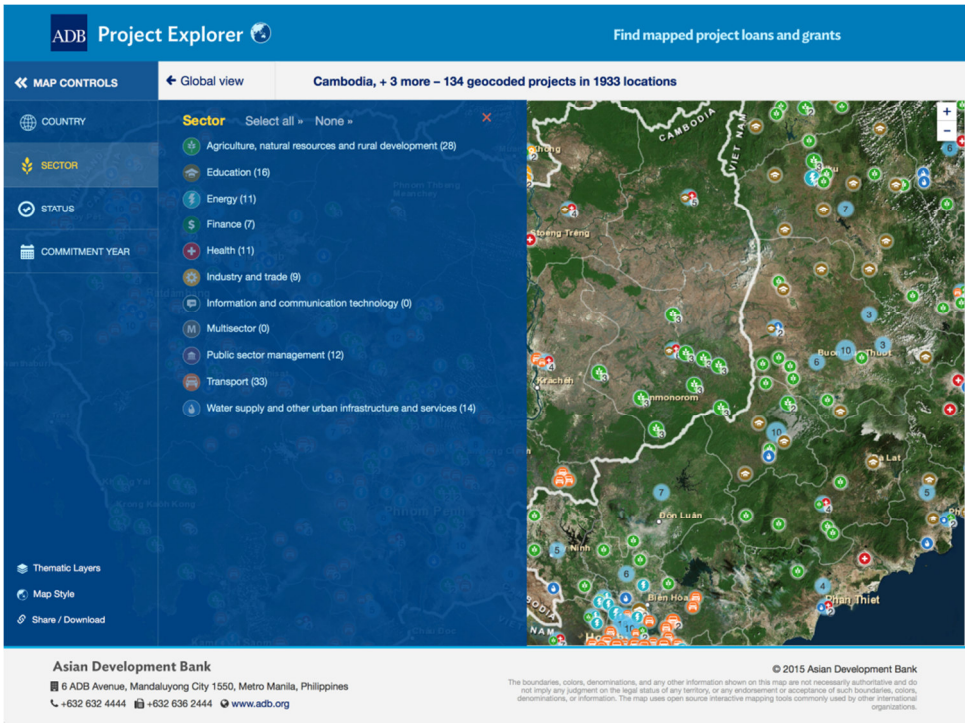
20. **Final version of the geomapping application.** Development Gateway initiated development of the geomapping platform in February 2015. From March 2015 to December 2015, Development Gateway submitted several test iterations of the application to ADB for its review and approval, culminating in the final version that was released in December 2015. In addition to the feedback rounds, ADB also conducted user and usability testing with several ADB staff members (e.g. potential users of the application) to ensure that the application was as user-friendly as possible. Feedback from the usability testing was provided to Development Gateway, and enhancements and improvements were incorporated to ensure the application's user-friendliness and intuitiveness.

21. The geomapping application has the following features:

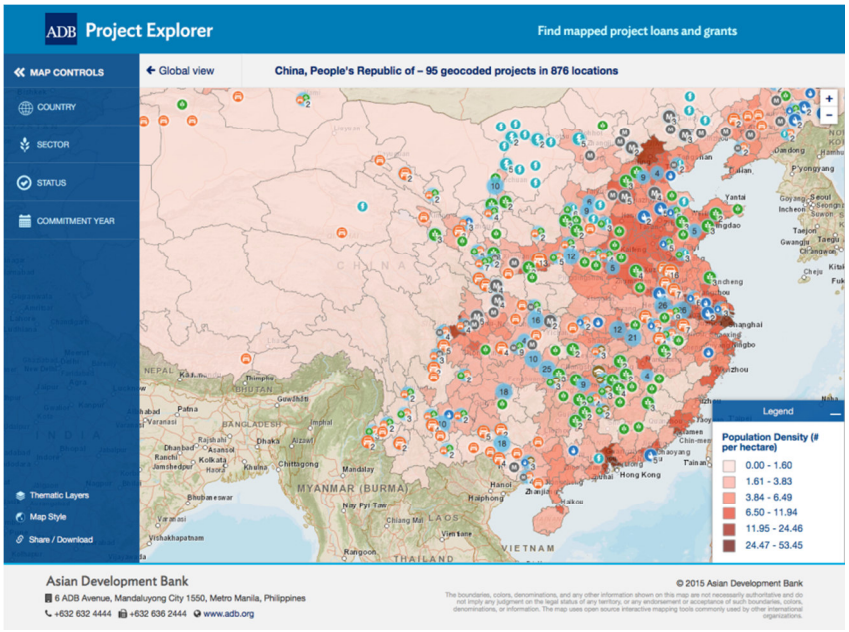
- A landing page, that shows bubbles per countries where ADB has geocoded projects



- A country page view, that shows project locations within a specific country. A user has the ability to also:
    - Include additional countries to view via a Map Control toolbar
    - Filter locations by specific ADB sector(s)
    - Filter locations by project status (active or closed)
    - Filter locations by project commitment year(s)



- Apply subnational thematic layers (currently: population density and infant mortality)[1] to help contextualize project location information



[1] Population density data is derived from WorldPop and infant mortality from DHS (Demographic and Health Surveys). The data is static; any updates to the data would need to be done from the application's backend.

- View World Bank or UNDP project locations, as reported to IATI, alongside ADB project locations, Since IATI information is used to populate the World Bank and UNDP project data, the data is updated at the same time when the IATI update is run for updating ADB's data. Given the nature of online interactive maps, ADB does not control the base maps that are used and the national boundaries or geographic names used in the tool. Therefore a disclaimer to this effect is provided in the current version, in the grey banner in the lower righthand corner of the geomapping application.
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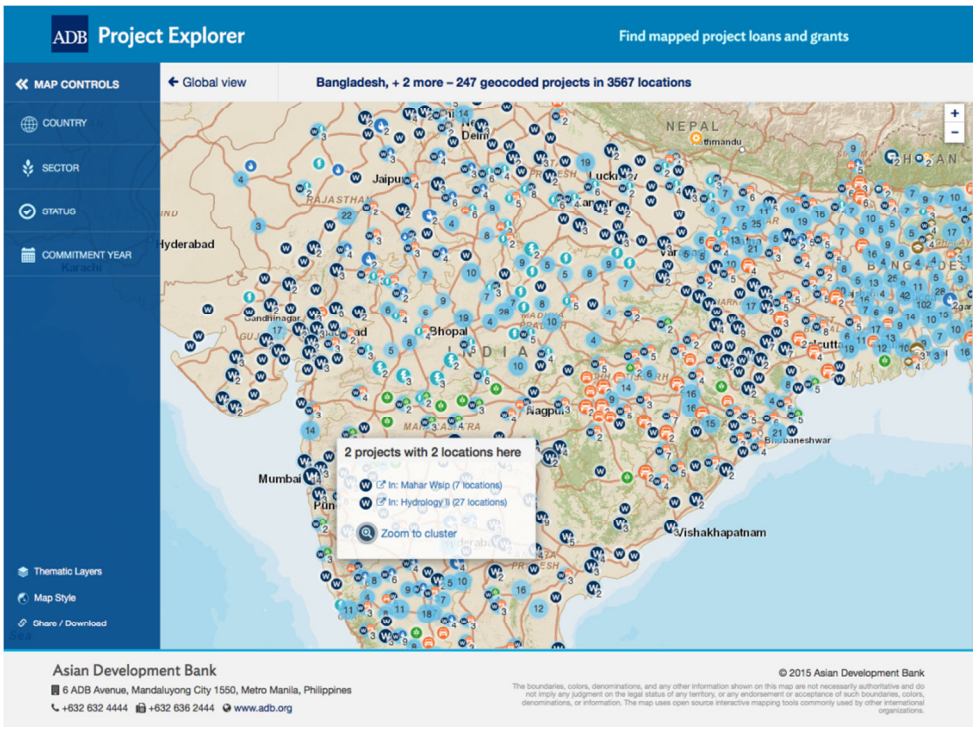
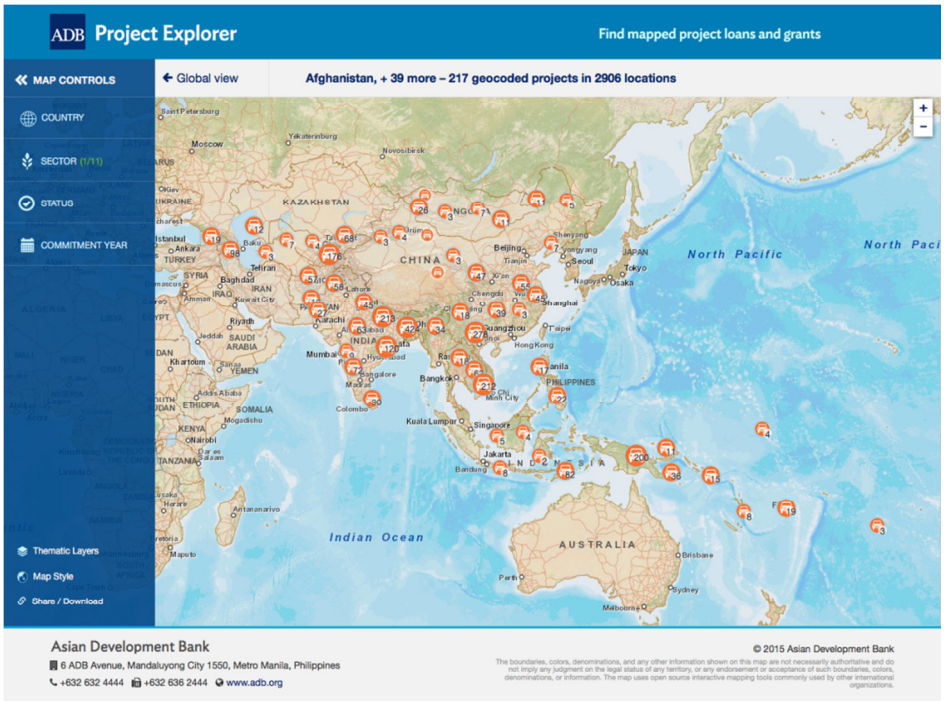
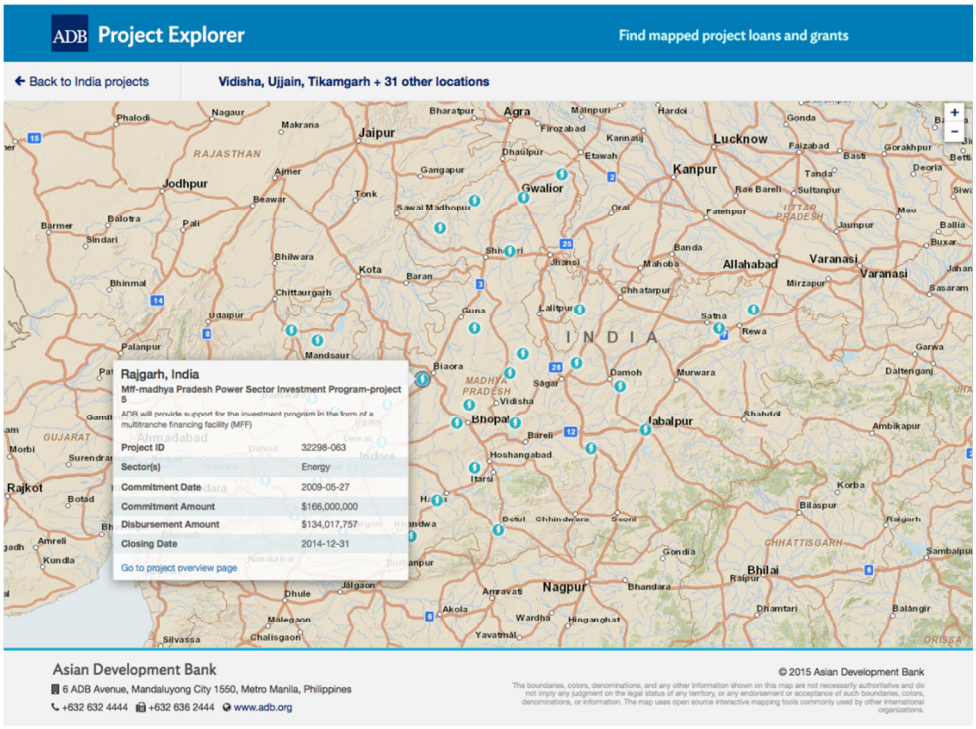


- A sector page view, that shows project locations per specific ADB sector(s)



- A project page view that shows project locations for a specific project



22. **Maintenance of the geocoding widget and geomapping application.** Development Gateway worked to ensure that both the geocoding widget and geocoding application were properly maintained throughout the course of this TA. Development Gateway bug fixed as well as addressed any issues of performance when issues as such appeared.

23. **Hosting of the geomapping application.** Development Gateway hosted the geomapping application on its own internal server throughout the course of this TA. In addition to hosting the application, Development Gateway also maintained the server to ensure the application did not suffer from any downtime and/or any server-related issues.

24. Development Gateway will also ensure that all necessary training and documentation materials, according to ADB's standards, will be provided to the necessary focal points if and when ADB takes over the handover of the hosting and maintenance of the application. Regarding overall usability of the application, DG will discuss with ADB during the application's launch process what types of user manuals and documentation need to be produced to ensure successful uptake of the application.

IV. RECOMMENDATIONS AND FOLLOW-UP ACTIONS

25. **Open-sourcing.** Given ADB's pioneer approach in utilizing its own IATI information as the data source for its geomapping application, we recommend that ADB open sources the geomapping application so that other donors can build upon and use the geomapping application in their own geocoded information visualization efforts. This would represent a significant contribution to the IATI community, allowing other IATI publishers to more easily visualize their data in interactive maps. Sharing this resource may also incentivize other IATI publishers to include geocoded data in their IATI portfolios, by providing a clear method through which they can use the data. Other IATI publishers have approached Development Gateway to inquire whether ADB would consider open-sourcing its application, upon learning of the integration with ADB's IATI data.

26. **ADB geocoded data quality checks.** Given that project officers are now the ones inputting geocoded information about their projects into ADB's eOperations system, we recommend that ADB consider doing a random data quality check to ensure that the entered location data is correct and of good quality as well as provide additional training if there is a need to do so.

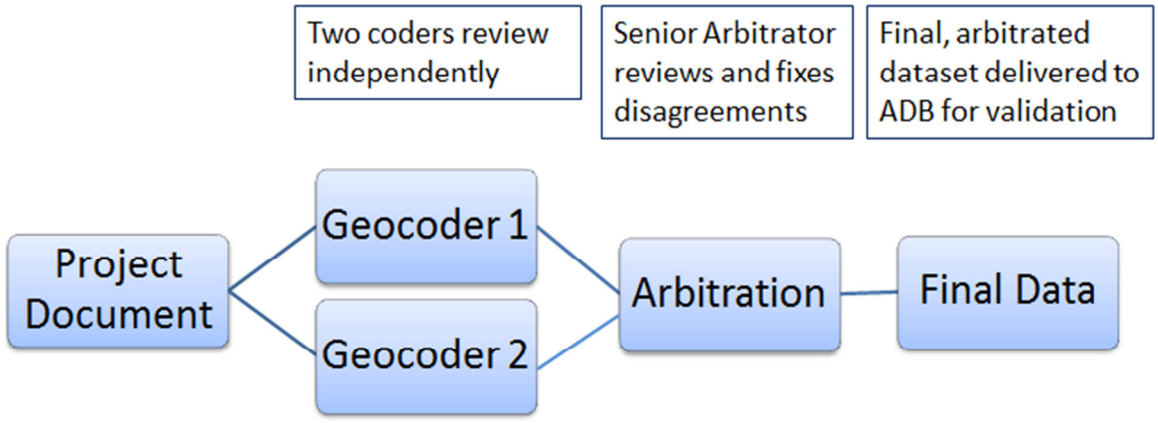
27. **Determining hosting and maintenance arrangement after 2016.** The key activities to be implemented by Development Gateway in early 2016 are focused on ensuring that the geomapping application is hosted effectively and that there is a maintenance contract in place to cover both the geocoding widget and geomapping applications, However, beyond the length of this TA and the hosting and maintenance arrangements for next year, Development Gateway will work with ADB to ensure that it is properly positioned to ensure that it is well-equipped to make decisions regarding the hosting, maintenance, and updating of the geomapping application and related data from 2017 onwards. These activities include i) ensuring the availability of necessary GIS skills for data maintenance and updating, ii) transition of application and indicator layers from DG hosting to ADB hosting arrangements, if ADB chooses to host the application in 2017 and beyond and iii) arrangements for annual application maintenance to reduce risks of downtime or bugs which negatively impact the experience of users.

V. ANNEX 1: GEOCODING PROCESS

The geocoded data is delivered in .xls format, with each row representing one project location and multiple rows for projects with multiple locations. Included fields, at a minimum, are Project ID, Approval ID, Project Title, Latitude, Longitude, Geoname, ADM1 Name, ADM2 Name, Activity Description, Source URL, and Country. Other fields may be included based upon Development Gateway discretion or ADB request. To incorporate an internal validation review by ADB, these .xls data will be filtered by ADB to include only the desired projects for validation and will then be uploaded into the validation tool. OIST will generate a bulk email to the project contacts, including the URL for their project, requesting them to validate the activities. At the conclusion of the validation period (approximately 2 weeks), ADB sends a log of the identified discrepancies to Development Gateway, who will incorporate the corrections into a final dataset. The final dataset will then be prepared for import into eOps.

The geocoding and validation process are visualized below:

Figure 1. Geocoding process.



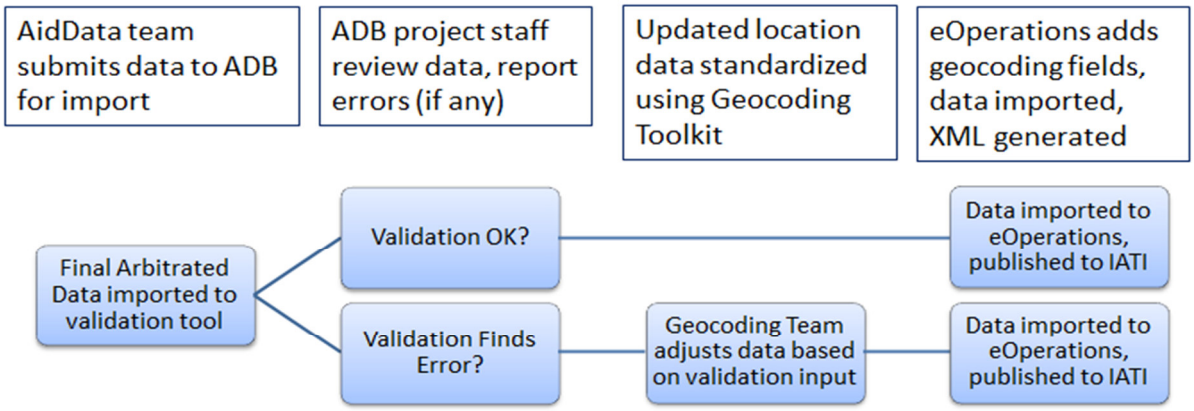


Figure 2. Validation process.

The validation tool, built using PostgreSQL and Google Maps, allows users to validate locations, correct them on the map, or provide comments on how the location information can be refined. Users will be informed via email - generated in bulk and sent to the project officers - of their requested validation task and can access a map of their specific project locations. Validation will take place for a selected sub-set of projects in the ADB portfolio (see below for more detail). The initial tool and proposed process was reviewed as part of the technical assessment under the prior TA and some small improvements were implemented prior to the initial validation exercise.

VI. ANNEX 2: SERVER RECOMMENDATIONS RESEARCH

This annex describes in detail the research that was undertaken to provide the server recommendations for the long-term hosting of the geomapping application.

We recommend either a t2.medium or a t2.large server, with the following specifications to host the geomapping application:

CPU: 2+ logical cores recommended
RAM: at least 1GB, 2GB+ recommended
Storage: at least 10GB, 20GB+ SSD recommended
Bandwidth: 1GB/s link can serve about 120 clients per second simultaneously; realistically, about 500 users should be able to comfortably work (if server-side & client-side caching and pre-compression are configured properly; assuming no SSL/TLS encryption). However, it is important to note we have developed the application to perform as best as possible given low-bandwidth contexts.
Server type: the server can be a virtual machine. For example, in Amazon EC2 the t2.small instance would be the minimal sufficient configuration for the static resources and users' limited use of ArcGIS Server for pre-cached thematic layers. A t2.medium + server configuration is recommended.

Regarding recommended vendors, Amazon is the foremost web services operator with the largest client base internationally. Its CloudFront CDN can provide static content delivery across 5 continents.

The following assumptions (Figure 1) were made in order to provide the aforementioned recommended specifications:

Figure 1. Expected Average Visit Sizes to the Geomapping Application and Google Performance Indicators for ADB's Current Website (as of November 2014).

Estimate: If every ADB pageload went to the map application:

	Visits /yr	Visits/mo	Visits/week	Visits/day	Visits/min	Visits/sec	Average visit size: 4 MB/mo
All visitors (average	4,826,543	402,212	92,818	13,260	9.2	**0.2**	**1,608,848 MB/mo**
Burst of visitors (x30)	144,796,29	12,066,358	2,784,544	397,792	276.2	**4.6**	48,265,430 MB/mo
Only mobile visitors	624,461	52,038	12,009	1,716	1.2	0.0	208,154 MB/mo
Burst w/o Mobile	126,062,46	10,505,205	2,424,278	346,325	240.5	**4.0**	42,020,820 MB/mo
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Estimate: visitors to project pages map	2,101,041	175,087	40,405	5,772	4.0	**0.07**	**700,347 MB/mo**

Google Analytics Key Performance Indicator

1 Dec 2013 - 30 Nov 2014

	Year Figure	Avg per day
Sessions	4,826,543	13,233
Users	2,856,580	7,826
Pageviews	16,623,217	45,543
Pages / Session	3.44	

Full ADB.org Bandwidth (avg)
20 TB / month

We made the above calculations of web application views anticipated to the project pages of the ADB site. We conservatively assumed the map will be loaded by 50% of visitors to the ADB.org website and that on average the use will be about 4MB of static content traffic. The web server was specified to support the visits per second as shown above in both regular and bursting circumstances. At this stage, mobile visitors will not use the geomapping application and so have been excluded. We are adding a 12% margin onto our bandwidth expectations to anticipate up to 0.8 terabytes (800 gigabytes) per month of billed bandwidth. This margin should cover even mobile users if they are supported in the future.

Because of the international nature of ADB.org, we have also recommended use of CloudFront Content Delivery Network. The CloudFront service copies the static resources of the application onto edge servers for users to quickly access wherever they are in the world. It is worthwhile to note that the request is not constrained to travel around the world for each request. If it is adopted, the CDN may shift some of the bandwidth costs, lowering the overall cost of the servers.

1) The ADB-mappable IATI embed application is static and does not need a powerful server to decide how to construct it on every visit. Because the data changes quarterly, it is almost entirely cacheable by the client for up to a week. The largest individual API payload is 900KB compressed, while the average is 400KB, with a 1900KB download for all the ADB country APIs. Typical API accesses will be 5 per use. The main app is about 300KB compressed and is loaded only once if the user navigates to all 4 pages that have the map. A conservative per-user

bandwidth is 4 megabytes. Between all these calculations, our previous recommendations should be conservative for the substantial number of users that the ADB website serves.

2) Some small portion of users will access the thematic layer feature and its data. The maps for the thematic layers in the GIS server will be made up of pre-calculated "tiles" of maps representing various pieces of demographic information. The GIS server will not need to generate anything on demand so this will also be low demand in terms of server resources.

3) The primary base map tiles of the map which load on every view of the map are provided by ESRI's servers and do not need to be hosted.

Server costs (Amazon)

Components of cost:
0.8 TB bandwidth out/mo, 100GB bandwidth in/mo, 1 Public IP Address, 1 compute instance, hosted in US/Virginia (with basic Cloudfront CDN for providing static content in Asia).

On-demand cost (no yearly purchase):
Medium: http://calculator.s3.amazonaws.com/index.html#r=IAD&s=EC2&key=calc-4DF3A143-C06F-4468-98A9-8EFFA2FEFA35 ($122.31 x 12 months = $1,467.72/yr)

Large: http://calculator.s3.amazonaws.com/index.html#r=IAD&s=EC2&key=calc-0A2DFC5D-7C83-4836-AC94-D6FAA84B4D9F
($160.37 x 12 months = $1,924.44/yr)

With yearly discount:
Medium: http://calculator.s3.amazonaws.com/index.html#r=IAD&s=EC2&key=calc-1CE60676-63BA-4782-87DF-330F01D545EB ($110.52 x 12 months = $1,326.24/yr)

Large: http://calculator.s3.amazonaws.com/index.html#r=IAD&s=EC2&key=calc-96CB9035-5C9F-463A-A8DB-556CD07E0C24 ($136.80 x 12 months = $1,665.60/yr)

Additional CloudFront CDN cost (for Asian redistribution, optional):
http://calculator.s3.amazonaws.com/index.html#s=CloudFront&key=calc-EC8C5F88-24B9-4665-8326-F37144C5E4FE ($192.30 x 12 months = $2,307.60/yr)

Server costs (Rackspace)

Components of cost:
0.5 TB CDN traffic, 0.5 TB server traffic, 1 public IP address, 1 virtual server (4 virtual cores, 4 GB RAM): ($263.44 × 12 months = $3,161.28/yr)
0.5 TB CDN traffic, 0.5 TB server traffic, 1 public IP address, 1 virtual server (8 virtual cores, 8 GB RAM): ($356.88 × 12 months = $4,282.56/yr)

Server costs (Leaseweb)

Components of cost:
1 TB mixed CDN and server traffic (4 virtual cores, 4 GB RAM): (($26.96 + $49) × 12 months = $911.52/yr)
1 TB mixed CDN and server traffic (8 virtual cores, 8 GB RAM): (($44.96 + $49) × 12 months = $1,127.52/yr)

VIII. ANNEX 3: SUGGESTED RESOURCING PROFILES, IN THE EVENT ADB TAKES OVER MAINTENANCE OF THE GEOMAPPING APPLICATION 2017 ONWARDS

The following list gives an overview of the necessary resources and skills needed for any ADB personnel involved in the maintenance of the geomapping application, if ADB were to take over the maintenance of the geomapping application from 2017 onwards. These profiles were developed in discussion with ADB over the course of the TA. The midterm report Development Gateway submitted to ADB on the various Long-term Hosting and Maintenance Arrangements served as the basis for ADB to decide which route(s) it wanted to take regarding hosting and maintenance of the geomapping application, at least for the following year (2016).

GIS Specialist profile

Ability to find, evaluate, process, and publish high-quality geospatial layers using desktop GIS software. Basic cartographic skills to ensure the publication of attractive layers that match ADB theming and design of geomapping portal. Ability to do basic administration of ArcGIS Server (e.g. publication of services, restarting services, making layers public/private). This Specialist would also support Country Offices when questions regarding geocoding or geospatial data collection are raised. Depending upon the ambitions of ADB to include statistical layers throughout its geomapping work, and the anticipated level of Country Office support, this would likely require 50-100 days per year.

Systems Administrator profile

Work experience with any RedHat-like Linux distribution (RHEL, CentOS, Fedora, Scientific etc). Experience in configuring the following software: Nginx web server (configuring forward proxying, compression, caching, headers), SSH server, fail2ban, any backup system (e.g. Bacula, AMANDA, Duplicity), LVM, YUM. Using OpenSSL to generate public/private key pair and certificate signing request. Experience in Linux networking, understanding how HTTP and SSL/TLS layers work.

X. ANNEX 4: LONGTERM HOSTING AND MAINTENANCE COMPARATIVE OPTIONS ANALYSIS

16. Recognizing the need for the resources listed above in Annex 3, if ADB were to take over hosting and maintenance of the geomapping application from 2017 onward, there are multiple paths through which ADB could fulfill these skill requirements. Three main paths were analyzed for this report and which were discussed with ADB throughout the course of the TA: 1) use of existing in-house GIS capacity (requiring repurposing of existing ADB GIS resources), 2) local or international contractors, and 3) secondment or other collaboration with the World Bank. Table 1 below details the comparative desirability of each option within key criteria. Based upon this analysis, the experiences of other MDBs and bilateral donors with GIS implementations, and the costing analysis (see below), DG makes the following recommendations:

17. It is recommended that ADB attempt to dedicate a minimum of 50 days per year from existing GIS staff/consulting resources within ADB. This represents the least cost option, which also provides the highest level of responsiveness to ADB needs. If such internal resources are unavailable, DG recommends the use of a local GIS consulting firm for approximately 100[2] consulting days per year to update and maintain the indicator data used within the geomapping application. This will be more cost effective than hiring a full-time staff/consultant due to the part-time nature of the work, while remaining more responsive and efficient than reliance upon World Bank capacity. While this approach and level of investment will not match the World Bank or Inter-American Development Bank GIS programs, it will place ADB ahead of the African Development Bank, Islamic Development Bank, and European Bank for Reconstruction and Development by providing an up-to-date, professional, and intuitive mapping platform with fresh data reported to the IATI registry. This approach will also enable ADB to maintain its high standing in future Aid Transparency Index rankings.

18. It should be further noted that the World Bank is currently pursuing greater openness and standardization of its sub-national data, in partnership with DG partner Esri. If successful, this World Bank work would reduce the number of days required from either ADB staff or local consultants to maintain and update the data layers used in the geomapping application. However, as currently DG has been forced to work directly with source data from the Demographic and Health Survey (DHS) and other sources, rather than World Bank data (due to data coverage, comprehensiveness, and the availability of desired ADB layers), ADB should be cautious of over-reliance upon World Bank data or staff for its GIS needs.

[2] The discrepancy between 50 days minimum for internal GIS and 100 days for an external GIS consultant is due to i) efficiency gains from having in-house expertise with lower transaction costs, and ii) the assumption that having fewer updates to layers would be acceptable to avoid the need to tender and procure an external consultant at significantly higher cost. If 100 days of internal GIS capacity are available, it is recommended that they be dedicated in full to the GIS work.

Table 1: Comparison of GIS Capacity Alternatives			
Criteria	**Existing In-House GIS**	**Contracted GIS**	**World Bank**
Responsiveness of GIS function to ADB operations	**High:** in-house GIS specialists can be flexibly directed to high-priority GIS tasks on a day-to-day basis.	**Moderate:** If international consultant is selected, low responsiveness due to time zone differences and lack of local context. If local, moderate responsiveness, limited by availability of sufficient days to perform all necessary work or conflicts with other tasks or consultancies.	**Low:** Time zone differences and conflicting World Bank priorities limit responsiveness of World Bank staff to ADB priorities and day-to-day needs. Additionally, due to current turnover among World Bank staff, DG and ADB have had difficulty obtaining quick answers to its questions.
Cost of GIS capacity	**Low (no additional cost):** For basic maintenance of the geomapping application, this represents the least cost option.	**Moderate-High:** For basic maintenance of the geomapping application, this represents a moderate cost option. Using an international GIS consulting firm would lead to high costs (approximately $800-1500 per day, depending upon consulting firm and experience).	**Low:** Leveraging World Bank resources would likely reduce costs by limiting duplication of effort. If ADB seeks to simply re-use World Bank layers. Costs would likely increase in relation to the level of customized work required from World Bank, which has been high during existing TA.
Quality of GIS Skills	**Moderate-High:** Existing ADB GIS staff should have high capacity for mapping, layer creation, and basic data management tasks.	**Moderate:** Local consultants may have more limited GIS capacity than international consulting firms. However, for likely ADB needs, it is anticipated that either local or international consulting firms would possess adequate skills.	**Moderate:** World Bank statistical staff has largely excelled in its focus on national-level data. Sub-national data has been lower priority and does not have the same level of World Bank staffing or expertise.
Up-front transaction costs to initiate	**Moderate:** Identifying existing resources and creating arrangements for alterations of staff work plans may entail high transaction costs between SPD and other offices.	**Moderate:** Existing local firms with adequate GIS capacity are available, reducing the time for searching. However, ADB procurement of these services through competitive tendering processes may be time-consuming, as may be raising awareness of consultant to ADB context and goals.	**High:** Creating appropriate agreements between ADB and World Bank may require substantial time investment. Additionally, availability of World Bank staff for onboarding and briefing on ADB goals may require time.

Transaction costs over time	**Low:** Having an in-house GIS professional over multiple years will reduce transaction costs over time, due to high levels of institutional knowledge and understanding of routine tasks performed annually or more frequently.	**Moderate:** The consulting firm itself would retain institutional knowledge of ADB tasks and needs. However, turnover within consulting firms may lead to changes of focal points and frequent revisiting of operating procedures and needs.	**High:** Coordinating the work of World Bank staff for ADB is likely to create an ongoing need for frequent communication. This may require high-level cooperation between ADB and World Bank management. Finally, turnover among World Bank staff may lead to lower levels of institutional knowledge, as ADB tasks are likely to be of lower priority than World Bank tasks.

COSTING

19. For basic maintenance, if in-house capacity is unavailable, it is recommended that ADB work with a local GIS firm, as it is unlikely that these tasks would require a full-time equivalent or international expertise. All costs have been classified as annual or one-time, and optional costs are identified as such.

20. License costs for ArcGIS Server are optional, as ADB has purchased a perpetual license. However, maintaining current license status entitles ADB to upgrades to the latest versions of ArcGIS Server, providing access to the most up-to-date functionality.

21. The annual maintenance contract with Development Gateway will include a service level agreement (SLA) for bug-fixing and other routine maintenance (e.g. updating labeling within maps). DG would designate a project manager and developer to respond to ADB requests, available by email, phone, or instant messaging services. This maintenance agreement would not include hosting or server administration (priced separately for a 3rd party provider).

22. Table 2 details expected annual costs, under the scenario that ADB is successful in identifying internal resources to maintain and update its geospatial data layers used in the geomapping application.

Table 2: Geomapping Maintenance Costs (with Existing ADB Resources)

Description	Units	Unit Cost	Annual or One-Time	Total
Hosting (including CloudFront CDN)	1	$4,000	Annual	$4,000
ArcGIS Server License	1	$5,000	Annual (Optional)	$5,000
Geomapping Maintenance Contract	1	$10,000	Annual	$10,000
			Total	$19,000

23. Table 3 details expected annual costs, assuming that ADB finds it necessary to procure external GIS support with a local contractor. GIS support days are budgeted for a high-capacity

local consulting firm. DG received quotes of approximately $488 for a junior GIS specialist and $588 for a senior GIS specialist. If external consultants are necessary, a senior GIS specialist is likely more appropriate, to ensure high quality outputs for ADB public facing maps. By comparison, International GIS experts through professional firms typically cost within the range of $800 (junior consultant, small firm) to $2000 (senior consultant, large firm). As the needs of ADB for the GIS consultant are unlikely to require international expertise, the lower cost option of identifying a local GIS consulting firm is preferred. In either case, a full and open tendering process is anticipated for compliance with ADB procurement procedures.

Table 3: Geomapping Maintenance Costs (with local contractor)				
Description	Units	Unit Cost	Annual or One-Time	Total
Hosting (including CloudFront CDN)	1	$4,000	Annual	$4,000
ArcGIS Server License	1	$5,000	Annual (Optional)	$5,000
Geomapping Maintenance Contract	1	$10,000	Annual	$10,000
GIS Support (Days)	100	$588	Annual	$58,800
			Total	$77,800

XI.

XIII. ANNEX 5: LONGTERM MIGRATION SCENARIOS BASED OFF OF VARIOUS HOSTING OPTIONS CONSIDERED

1. DG will host and maintain the geomapping application over the course of 2016. However, the following diagrams detail the various different hosting scenarios of the ADB geomapping application, if ADB chooses to take over hosting and maintenance from 2017 onward. These scenarios were developed in discussion with ADB over the course of the TA. The midterm report Development Gateway submitted to ADB on the various Long-term Hosting and Maintenance Arrangements served as the basis for ADB to decide which route(s) it wanted to take regarding hosting and maintenance of the geomapping application, at least for the following year (2016).

Clarification of primary embed (as used on adbdev.org)

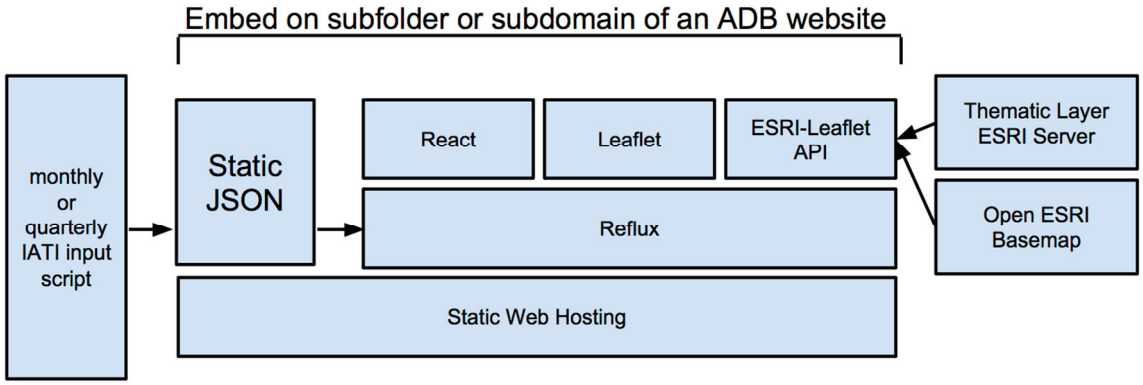

Figure 1. Geomapping Application Architecture

2. The application consists of four essential view modes: Project Landing page, Country page, Sector page, and Project Page. Each of these are linkable by appending one of these strings to the base URL (e.g. http://adbdev.org/projects/map):

- **#/ => Map Project Landing Page**
- **#/countries?c[]=IN** (where IN is the two letter IATI/ISO2 code, multiple can be specified, as in #/countries?c[]=IN,c[]=LK and special characters "[]" will often be url-escaped to %5B%5D. Listed in suggested-url-mapping.xlsx) **=> Country Page**
- **#/sector/Energy** (where Energy is a code from the suggested-url-mapping.xlsx). See http://devgateway.github.io/asdb-gis-dashboard/605d6c/projects/#/sector/Energy to test) **=> Sector Page**
- **#/projects/39619-013** or **#/projects/LK/39619-013** (with navigation back to country) where 396019-013 is the valid 8-digits sub-code of at least one IATI activity code that has been released before the most recent run of the IATI update script. **=> Project Page**
- **#/countries?c[]=IN&iati[]=worldbank.IN** (where IN is the two letter IATI/ISO2 code, and special characters "[]" will often be url-escaped to %5B%5D. Listed in suggested-url-mapping.xlsx) **=> World Bank/UNDP IATI Location Thematic Layers**

3. The input data to the application is built using a Python script that ADB consultants or staff will run on the same schedule as IATI updates. When that script is run, it will upload its results

to a private git repository and GitHub Pages hosted on GitHub, updating the static API underlying the static JavaScript application.

4. The web server and/or CDN synchronize their static content with the git repository using a reverse proxy facing Github Pages, either updating the data of the same script or providing a new version with embed URL, depending on the options.

Development Gateway-hosted (as currently used for adbdev.org)

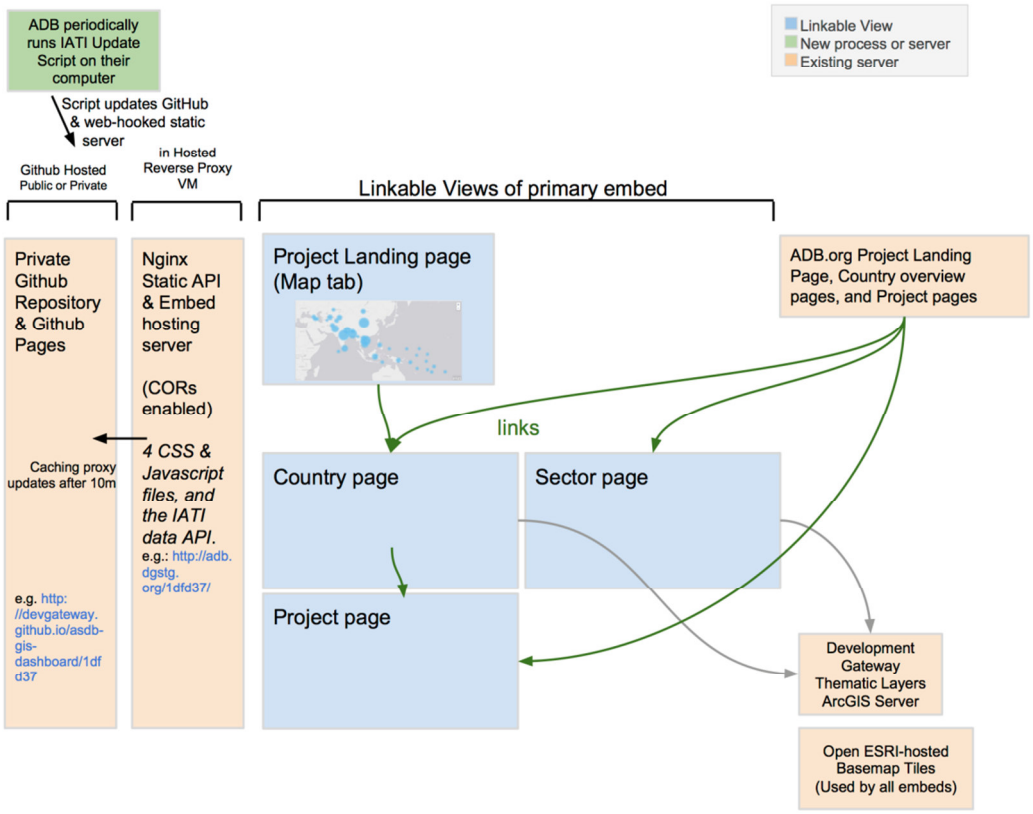

Figure 2. DG-Hosted Hosting Scenario

5. The box on the left shows the server where the reference API and application are hosted in Github Pages. Next to it, on the right, the Nginx static web server (hosted by DG) handles requests from the Internet for the JavaScript code and data APIs. If they have been seen in the past ten minutes, the contents from the cache are returned, otherwise it forwards unrecognized requests on to Github Pages server and saves what it responds with into the cache, passing it back to the original requestor (this is “reverse proxying”).

6. The Python IATI script process will be carried out to update the underlying data whenever (currently quarterly) ADB approves and releases IATI XML. The IATI script process writes any changes of the project locations to Github Pages using ADB consultant or employee Github

credentials. Through this process, there is no need to define direct access to the server resources of the application.

7. In the Development Gateway scenario, the Thematic Layer ArcGIS Server is hosted in Virginia at a data center. It is accessed when a user chooses to display a particular sub-national, thematic layer. This would not require the procurement of a new server as the layers are hosted on an existing server license.

8. Each of the distinct views, shown in blue, are loaded using the same JavaScript code and data APIs (that are reverse proxied by the Nginx static server to Github when needed). Only the sector and country page have thematic layers. The DER-maintained adb.org pages link directly to their appropriate views.

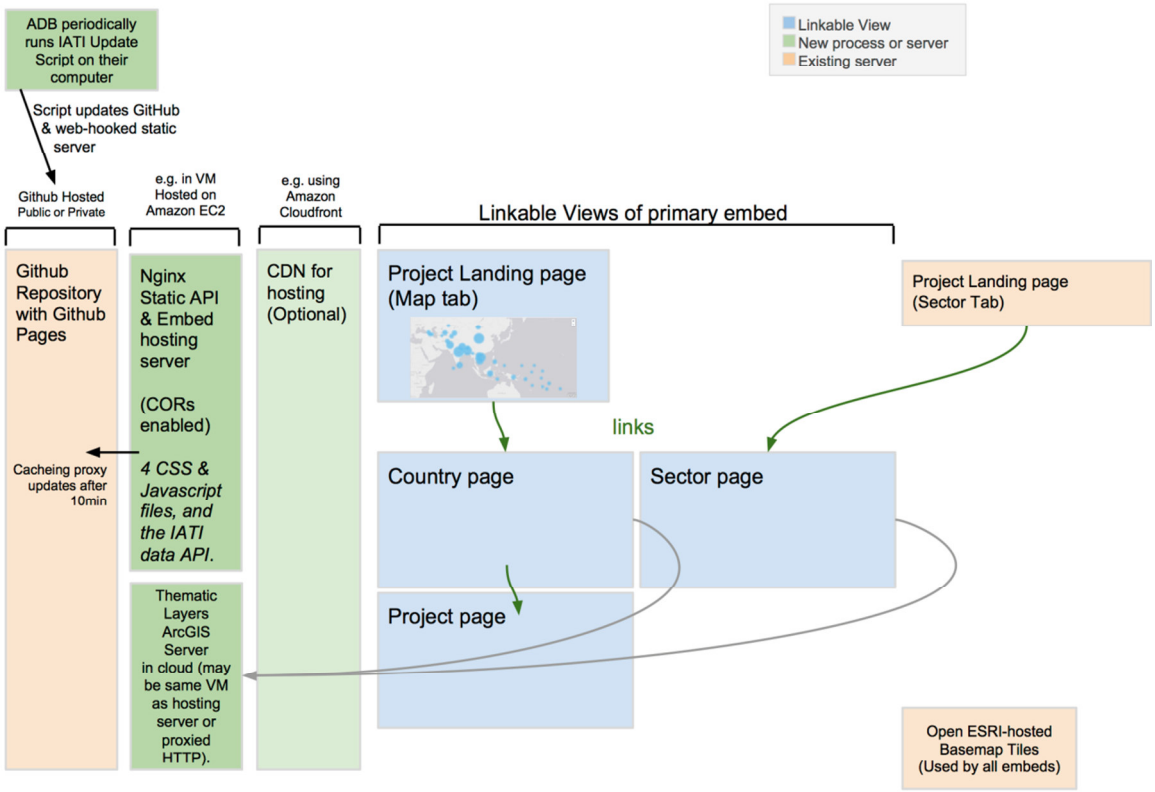

Figure 3. Cloud Hosted Hosting Scenario

9. The box on the left shows the server where the reference API and application are hosted in Github Pages. Next to it, on the right, the Nginx static web server (hosted on a 3rd party cloud environment) handles requests from the Internet for the JavaScript code and data APIs. If they have been seen in the past ten minutes, the contents from the cache are returned, otherwise it forwards unrecognized requests on to Github Pages server and saves what it responds with into the cache, passing it back to the original requestor (This is “reverse proxying”).

10. The Python IATI script process will be carried out to update the underlying data whenever (currently quarterly) ADB approves and releases IATI XML. The IATI script process writes any

changes of the project locations to Github Pages using ADB consultant or employee Github credentials. Through this process, there is no need to define direct access to the server resources of the application.

11. In the Cloud Hosted scenario, the Thematic Layer ArcGIS Server is hosted on an ADB selected cloud service at a data center. It can be the same server as the application server or a distinct server, but the current budgeting allocates it as the same. It is accessed when a user chooses to display a particular sub-national, thematic layer.

12. If a CDN is implemented, it would act as a second reverse proxy web server of static resources, except it would be geographically distributed for optimal speed whether the visitor is in Manila, Kyrgyzstan or Paris, for example.

13. Each of the distinct views, shown in blue, are loaded using the same JavaScript code and data APIs (that are reverse proxied by the Nginx static server and/or CDN to Github when needed). Only the sector and country page have thematic layers. The DER-maintained adb.org pages link directly to their appropriate views.

Some ADB-internal hosting crosses firewalls

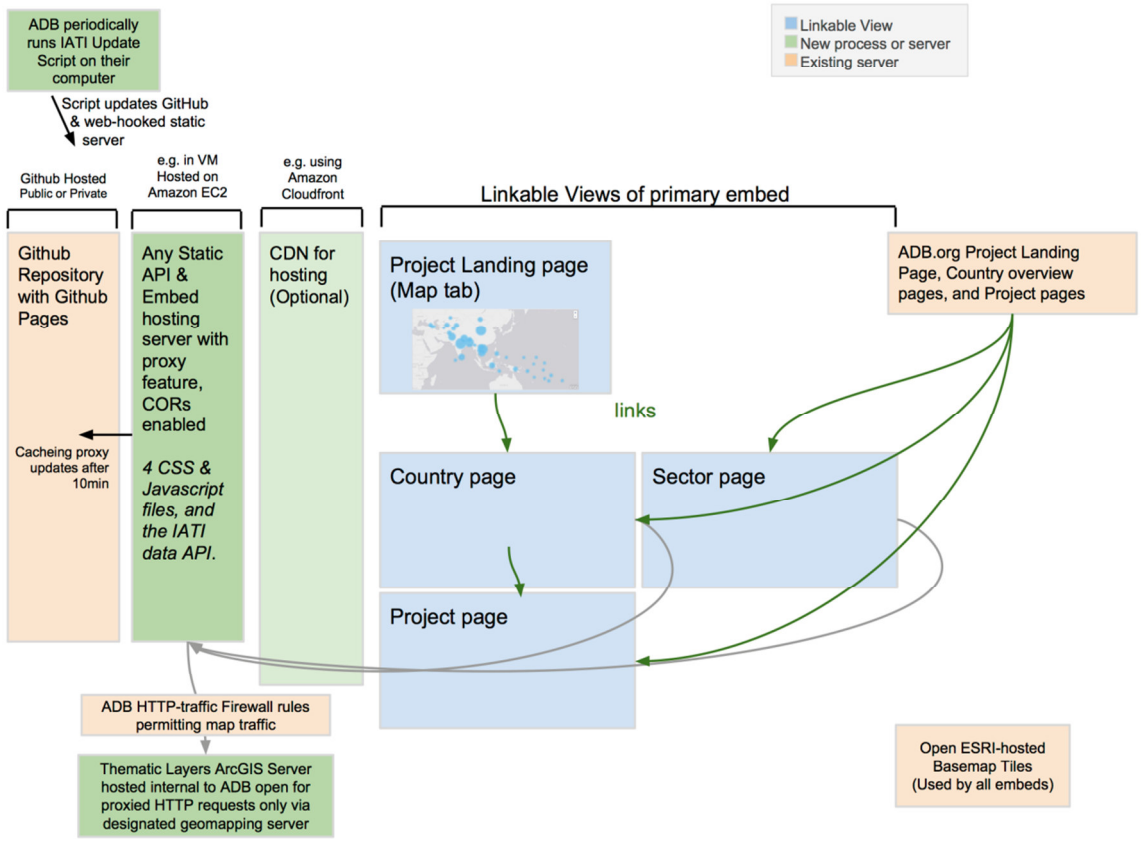

Figure 4. Some ADB Internal Hosting Scenario

14. The primary distinguishing aspect of the final hosting scenario is that the ArcGIS Server might be hosted inside ADB's corporate firewall. The Static API & Embeddable application web server will access Github Pages to cache content to serve just as in scenarios described above.

15. If a CDN was employed, the static API & embeddable application server could be within a firewall and be narrowly permitted to access only Github, the Thematic Layer ArcGIS Server and to be accessed by the CDN. This is not recommended.

16. Access to the map tile resources on the ArcGIS Server would be reverse proxied in a similar manner as the Github Pages server so they were always speedy (as soon as maps are visited once at relevant zoom levels) regardless of the status of the connection into the firewall. One part of the URL structure for the web server would forward/map across virtually to the ArcGIS server and the rest would forward/map across virtually to Github Pages.

Hosting scenario recommendation

17. It is the recommendation of DG that the existing ArcGIS server be moved outside of the ADB firewall (see hosting diagram, cloud hosted scenario for reference) in order to support the hosting of indicator layers for the geomapping application. The third scenario may be unnecessary because though it was included with the procurement, the final eOps "widget" application was not configured to reference any ArcGIS server. DG can assist OIST in the process of de-provisioning the existing server installation and configuring the ArcGIS server on a publicly accessible Windows server outside of the ADB firewall, according to the final hosting decision (DG-hosted, 3rd party cloud-hosted, or ADB-hosted) made by ADB. DG will also assist in publishing the indicator layers to the relocated ArcGIS server.

XV. ANNEX 6: CHECKLIST FOR HANDOVER OF GEOMAPPING APPLICATION TO ADB

The following checklist marks all the activities that need to occur in order to ensure a successful migration of hosting and maintenance of the geomapping application to ADB, should ADB decide to take over the hosting and maintenance of the application. If that is indeed the case, the responsible ADB departments for the following tasks should be identified and defined by ADB to ensure clarity of roles and responsibilities.

All indicative costs associated with long-term hosting and maintenance are in **bold** below for ADB's reference.

Github Repository

- Determine whether to Open Source tool. It is important to note that there will be no need to "migrate" the application to a different platform should ADB decide to open source the application. It is a matter of deciding whether to have the code accessible openly on GitHub or not.
- If open source is selected, the one thing that will need to be decided upon is the license type to be utilized. DG can support this process as well if that is the route that ADB chooses.
- Create public organization on Github using a pre-existing GitHub account: e.g. https://github.com/asiandevbank
- **If tool is private and not Open Source, purchase $25/month organization account.** It is worth noting that other organizations, such as UN Open and DfID, have chosen to use open repositories for this purpose.
- DG will transfer ownership of https://github.com/devgateway/asdb-gis-dashboard/ repository to ADB.
- ADB will authorize DG members as contributors on this repository.
- ADB will authorize any users of the IATI update script on this repository.

Web Server

- Create a new Linux or Windows machine. DG is using Linux for both servers.
    - If purchasing a new, cloud server, we recommend the following:
    - Amazon Large Linux Instance **(approximately $4,000/yr, including CDN costs[3]).**
    - **Without CDN costs**, annual costs would be approximately **$2,000/yr.**
- Install reverse proxy web server.
- For Linux, Nginx is recommended (see example config file at https://gist.github.com/thadk/40751f995c3992918fe1)
- For Windows, either Nginx or Apache will work.

[3] A **content delivery network** or **content distribution network** (**CDN**) is a large distributed system of servers deployed in multiple data centers across the Internet so that access to individual static resources is prompt and available in all parts of the world. An example of one CDN would be Amazon's Cloudfront. CDN costs, to an extent, offset bandwidth costs on the cloud server but this cannot be precisely anticipated.

    - If purchasing a new, cloud server, we recommend the following:
    - Amazon Large Windows Instance **(approximately $4,700/yr, including CDN costs).**
    - **Without CDN costs**, annual costs would be approximately **$2,700/yr.**

Configure Reverse Proxy to

- Open up Cross-Origin Requests (CORS).
- Forward traffic to:
    - e.g. asiandevbank.github.com/asdb-gis-dashboard/release-v1
- Retain cache validity for 10 minutes.
- Update embed API & CSS reference in code base with new server name.
- Reference this new version of JavaScript in the HTML where it will be used.

ArcGIS Server

- De-authorize the ArcGIS license of the test server from the eOps tool (Marvin is familiar with this).
- Download ArcGIS server.
- Deploy it on a public-facing server (such as the web server configured above).
- Make sure ArcGIS is not using Port 80 if sharing a single server.
- Publish the approximately 51 country-level service definition (.SD) files provided by DG for each thematic layer. It is important to note that any updates to the following data will need to be done manually. It was not possible to automatically link this data to the geomapping application given that the data required specific formatting to be compatible with ADB standards and the application. However, we have created a detailed admin manual that walks through this process.
    - 28 WorldPop-based Sub-national Population Densities (India & China for ADM2/District, elsewhere ADM1/Region, all using 2015 adjusted estimates)
    - 5 PCRAFI-based Sub-national Small-Island Population Densities (2010 adjusted estimates) where WorldPop was not available.
    - 18 DHS-based Sub-national Infant Mortality (based on USG Demographics & Health Survey, using the latest survey for respective country, ranging from years roughly 1999 to 2012).
- The application code base will need to be updated with the ArcGIS server name and list of new services once published.
- Optionally (to improve caching or security if multiple machines):
    - Configure ArcGIS to only host on port 6080.
    - Close outside access to port 6080 on network or server.
    - Configure the Apache or Nginx web server to reverse proxy ArcGIS Services for ADBPublic folder (e.g. gis.developmentgateway.org/arcgis/rest/services/ADBPublic:6080 to port 80).

Important note: The ArcGIS server will be fully dedicated to the geomapping application. It can be used though for other geospatial publishing purposes if need be. However, we strongly recommend to not overload the server.

Maintenance Costs

- Decide on license costs for ArcGIS server.
    - License costs for ArcGIS Server are optional, as ADB has purchased a perpetual license. However, maintaining current license status entitles ADB to upgrades to the latest versions of ArcGIS Server, providing access to the most up-to-date functionality.
- Decide on who will provide maintenance for the geomapping application.
    - **DG.** The annual maintenance contract with Development Gateway will include a service level agreement (SLA) for bug-fixing and other routine maintenance (e.g. updating labeling within maps).
    - Table 1 details expected annual costs if DG provides maintenance, assuming that ADB is successful in identifying internal resources to maintain and update its geospatial data layers used in the geomapping application.

Table 1: Geomapping Maintenance Costs (with Existing ADB Resources)				
Description	Units	Unit Cost	Annual or One-Time	Total
ArcGIS Server License	1	$5,000	Annual (Optional)	**$5,000**
DG Geomapping Maintenance Contract	1	$10,000	Annual	**$10,000**

- Decide on whether to maintain updated indicator layers for the geomapping application and preferred approach to GIS maintenance.
    - **3rd party local firm.** For basic maintenance, it is recommended that ADB work with a local GIS firm, as it is unlikely that these tasks would require a full-time equivalent. However, if ADB seeks to scale its GIS to enterprise level, at least one in-house GIS specialist should be secured to support the Bank's efforts.
    - Table 2 details expected annual costs, assuming that ADB finds it necessary to procure external GIS support with a local contractor. GIS support days are budgeted for a high-capacity local consulting firm. DG received quotes of approximately $488 for a junior GIS specialist and $588 for a senior GIS specialist. If external consultants are necessary, a senior GIS specialist is likely more appropriate, to ensure high quality outputs for ADB public facing maps.

Table 2: Geomapping Maintenance Costs (with local contractor)				
Description	Units	Unit Cost	Annual or One-Time	Total
ArcGIS Server License	1	$5,000	Annual (Optional)	**$5,000**

GIS Support (Days)	100	$588	Annual	**$58,800**