Distr. General

E/ECA/CODIST/1/12
6 March 2009

UNITED NATIONS
ECONOMIC AND SOCIAL COUNCIL

Original: English

ECONOMIC COMMISSION FOR AFRICA

Committee on Development Information,
Science and Technology

First session
Addis Ababa, Ethiopia
28 April – 1 May 2009

Geoinformation perspectives on innovation and economic growth

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Abstract

1. Innovation does not come from organizations, but from individuals. Innovation will take place whatever the circumstances because people need to survive and hence will always strive to improve their lot. Governments can either stifle innovation, or encourage and facilitate it. Geoinformation and geographical information systems are essential for innovation and economic growth, for effective policy formulation and for planning, implementing and monitoring development projects. Geoinformation has many, including its well-known uses in resource management and urban planning. However, it has other innovative applications in the commercial sector, such as in precision farming, deployment and exploitation of communications systems, analysis of customer databases against outlet catchment areas, location-based services, customer relationship management, real estate and insurance.

2. There are also exciting, innovative applications in the creation of virtual globes (Google Earth) and user-generated content that exploit micropayment systems on the Internet. Unfortunately, access to information is often prevented by legislation or government control of the information source, such as mapping being controlled by the military. This is a particular problem with spatial data. Yet, there are virtual globes that provide a large volume of high–resolution data for free (though perhaps of unknown quality and without metadata). This paper will also consider the issues of intellectual property rights, standards and digital curation for innovation and economic growth.

Key words

3. Geoinformation, innovation, economic growth, spatial data infrastructure, address, location-based service, user-generated content, intellectual property rights, standard, digital curation.

1. Introduction

1.1 Background

1. This paper aims to provide geographical information (geoinformation) perspectives on innovation and economic growth in Africa. The theme of this first session of the Committee on Development Information, Science and Technology (CODIST-1) of the United Nations Economic Commission for Africa (UNECA) is *"Scientific development, innovation and the knowledge economy."* CODIST arose out of the Committee for Development Information (CODI), which had met five times before (all also in Addis Ababa, Ethiopia). The themes of these CODI meetings were:

- CODI-I, 1999: *Harnessing information for development*;
- CODI-II, 2001: *Development information and decision-making*;
- CODI-III, 2003: *Information and governance*;
- CODI-IV, 2005: *Information as an economic resource;* and
- CODI-V, 2007: *Employment and the knowledge economy* (UNECA 2009c).

2. As can be seen, "information" and/or "knowledge" have been common to all six of these themes. Unsurprisingly, they all generally of development or the economy, as the purpose of CODIST is to help address Africa's development challenges and to support the New Partnership for Africa's Development and the African Union Commission (UN ECA 2009b).

3. The new concepts introduced with CODIST-1 are "scientific development" and "innovation". Scientific development has been crucial for geoinformation, as it has produced the theories, techniques, systems and tools for capturing, integrating, managing, analysing, disseminating and using spatial data. Geoinformation has also contributed to scientific development in other fields, providing a platform for research and development that would otherwise not been possible.

4. Unfortunately, much of the scientific development and innovation has taken place outside Africa, However, CODIST needs to help African researchers and entrepreneurs engaged in scientific development and innovation that would be relevant to the needs of Africans and the African continent.

1.2. Scientific development, innovation and the knowledge economy

5. For CODIST-1, UNECA has circulated a concept note on the theme of scientific development, innovation and the knowledge economy (UNECA 2009a). This paper will address some of the issues raised in the concept note and will present some geoinformation perspectives on innovation and economic growth in Africa.

6. Innovation does not come from organizations, but from individuals. Innovation will take place whatever the circumstances because people need to survive and hence will always strive to improve their lot. Governments can either stifle innovation with excessive bureaucratic procedures (red tape) or restricted access to certain data, services or products, or they can encourage and facilitate it. Often, government attempts to protect State corporations impede innovation, but innovative entrepreneurs can overcome such barriers to threaten the viability of these protected State corporations, particularly as the Internet facilitates the

distribution of services and data across national boundaries. For example, the virtual globe Google Earth [Google 2009], which was released in 2005, poses a threat to national mapping agencies, while simultaneously raising public awareness of geoinformation and hence creating opportunities for mapping agencies that encourage innovation. Moon & Bretschneiber (2002) suggest that perceived red tape could facilitate innovation in information technology as organizations find ways of overcoming bureaucratic obstacles.

7. CODIST is essentially a political gathering or a "talk shop", but it needs to enhance its status by leveraging its authority and networks to source funding for projects to implement its recommendations. UNECA and CODIST also need to encourage African Governments to provide the legislative frameworks, policies and service delivery that foster innovation and hence economic growth.

Sed fugit interea, fugit inreparabile tempus.
"But meanwhile it is flying, irretrievable time is flying" (Virgil 29 BCE).

2. Geoinformation, innovation and economic growth

2.1. The nature of geoinformation

8. Geoinformation encompasses all information about all objects or phenomena that are directly or indirectly associated with a location on, above or below the Earth's surface. Geoinformation includes information about both real and imaginary objects and phenomena, that is, objects and phenomena that exist, have existed or might have existed, and that are planned, proposed or simulated. Geoinformation is generally used in geographical information systems (GIS), which combine spatial databases with tools for acquiring, processing, modelling, analysing and presenting the data. A key aspect of GIS is being able to integrate different data sets for greater leverage. Many of the data sets used in a GIS are obtained from outside the organization, such as imagery from remote-sensing satellites and aircraft, and fundamental data sets from national mapping and statistical agencies. Through its Working Group on Fundamental Data Sets, the Sub-committee for Geoinformation of CODIST (CODIST-Geo) has identified the fundamental data themes for Africa [Gyamfi-Aidoo *et al* 2006].

9. Geoinformation and GIS are essential for innovation and economic growth, for effective policy formulation and for planning, implementing and monitoring development projects, as suggested in paragraphs 30 and 32 of the CODIST-1 Concept Note (UNECA 2009a). However, many other geoinformation applications are identified in the Concept Note, including:

- *Agricultural research* (paragraph 25): Precision farming (varying sowing density and fertiliser and other inputs based on in-field variability), arable land exploration for high-value crops with precise environmental requirements (e.g. for essential oils), crop health monitoring (e.g. for futures trading), and assessing how agricultural practices will need to be adapted to counteract climate change;

- *Deployment and exploitation communications systems* (paragraph 26):

Selecting optimal sites for transmitters based on the terrain, clutter and demand for mobile services; and

- *Support for small, medium-sized and micro enterprises* (paragraph 28): Micropayment systems on the Internet which enable application service providers to provide small companies with access to sophisticated modelling and analysis software for routing, site selection or detailed weather forecasting. These services can also be provided directly to mobile telephones and similar devices.

10. As has been seen above, geoinformation has many applications. Those in resource management and urban planning are well known, but there are other innovative applications in the commercial sector, such as analysis of customer databases against outlet catchment areas, location-based services, real estate services, and public-private partnerships for urban renewal. Such applications are often known as *business geographics* or *location intelligence*.

11. The private sector in Africa funds a small proportion of the geoinformation produced for Africa, with much of the funding coming from development aid and Governments. Further, geoinformation professionals in Africa are employed primarily in government, followed by academia and quasi-government [Schwabe 2007]. While much of the data capture might be done by the private sector, its involvement is primarily passive (i.e. responding to tenders and the like). The private sector in Africa needs to be pro-active and to identify and exploit business geographics opportunities. Schwabe [2007] reports from a survey that the future growth of the geoinformation industry in Africa is "in the areas of telecommunications, disaster management, governance and policy development, location-based services, marketing and sales, environmental management and utility".

2.2. Spatial data infrastructures

12. The Concept Note (UNECA 2009a) highlights in paragraph 16 the importance of spatial data and spatial data infrastructure for the enabling environment for innovation. Spatial data infrastructure can also drive economic growth. For example, while the European Spatial data infrastructure known as INSPIRE (Infrastructure for Spatial Information in the European Community) is being established primarily to support the policies and activities of the European Community that affect on the environment, the European Directive establishing INSPIRE recognizes that it can stimulate the development of added-value services by third parties, for the benefit of both public authorities and the public (European Parliament 2007, Clause 26).

13. Unfortunately, the Concept Note (UNECA 2009a) makes no mention of the fact that access to information is often prevented by legislation or government control of the information source, such as mapping being controlled by the military. This is a particular problem with spatial data. Yet, there are virtual globes and geobrowsers such as Google Earth [Google 2009] and NASA World Wind (NASA 2009) that providing a large volume of high-resolution data for free (though perhaps of unknown quality and without adequate metadata). Limiting access to information also inhibits economic growth. For example, the European Directive on the re-use of public sector information recognizes that digital content production has created many jobs in recent years, particularly in small emerging companies. It also recognizes that "public sector information is an important primary material for digital content

products and services", and facilitating re-use of public sector information should "contribute to economic growth and job creation" (European Parliament, 2003).

2.3. Addresses

14. Key to the commercial exploitation of geoinformation is being able to combine different data sets, particularly those that use geographical identifiers (such as addresses) for their spatial referencing, as opposed to geographical coordinates. While computers might "prefer" to use coordinates for locating objects in spatial data sets, it is difficult for humans to use coordinates, even with the widespread use of global positioning system (GPS) devices and virtual globes. Humans prefer to use addresses containing intelligible names and contexts, such as a hierarchy of names (street, suburb, town, province and country). Addresses are used to facilitate delivery of different types of services (including postal services) by various providers [Coetzee & Cooper 2007b]. The economic benefits of an effective addressing system include:

- **Maintaining customer databases**, to allow companies to send invoices, ordered goods and promotional material to their customers, and if necessary, facilitate debt collection;

- **Retail outlet planning**, through spatial analysis of the addresses of customers against where they shop (obtained from their use of credit cards, etc), which can reveal gaps in the retail outlet network or outlet inventories inappropriate for their catchment; and

- **Routing delivery vehicles and managing their loads** (i.e. combining part loads) to save costs and make deliveries more predictable (hence providing a better service) (Coetzee & Cooper 2007a).

15. As discussed at the CODI-Geo ad hoc expert group meeting entitled "Geographic Data as a National Asset: Focus on Situs Addressing in 2005", a functional addressing system can also generate downstream economic activities, such as producing and maintaining up-to-date street maps and guides, and facilitating and encouraging local tourism, so that the destinations can actually be found in a maze of streets (CODI-Geo/DISD 2005).

16. However, as address data are obtained in different ways for an address database (e.g. paper forms or entered online), they often contain errors and ambiguities. For example, in the database of one large South African organization, the name of the town *Witbank* was recorded in the field for town names in over 200 different ways (Cooper 2007). For them to be integrated with other data sets, addresses also need to be geocoded, that is, matched to geographical coordinates. Address matching is also complicated by name changes and incomplete addresses. One approach to cleaning up address databases is to use weighted spatial adjacency searches with hierarchical address data structures (Rahed *et al* 2008).

17. Unfortunately, many African countries do not have comprehensive addressing systems providing addresses for all their citizens across the country. This applies particularly in informal settlements and deep rural areas with traditional leadership. The result is lost

revenue collection opportunities such as taxation, customer billing, foreign direct investments and tourism; time wastage; increased transaction costs; poor service delivery (particularly for emergency and security services), and the inability to provide location-based services (CODI-Geo/DISD 2005). Addresses are often needed to open a bank account, buy on credit, obtain a passport or vote. Having an address can also provide citizens with a social status, providing a sense of identity and of being recognized as a proper citizen (Coetzee & Cooper 2007b).

18. Addresses then tend to be informal in many parts of Africa, and are often given relative to a landmark. This lack of formal addresses applies to other parts of the world, such as Managua, Nicaragua, where most of the streets are unnamed (Rogers 2009). The South African Address Standard (SANS/DSS 1883-1:2009) aims to cover informal addresses as well as formal addresses, as both appear in South African address databases. There are also initiatives to develop an international address standard – see, for example, Coetzee *et al* (2008) and Cooper & Coetzee (2008).

2.4. Location-based services

19. Most geoinformation is static, needing only periodic updates. Examples include cadastral boundaries, geological features, transportation networks and land cover. However, there is a growing availability and use of dynamic geoinformation, such as real-time traffic conditions, weather data, river water levels and closed-circuit surveillance systems. The proliferation of mobile devices that can be tracked by incorporating GPS receivers or using triangulation of signal strengths on mobile telephone networks or other wireless networks (e.g. WiFi, WiMAX, Bluetooth or RFID), has led to the development of location-based services (LBS) that use the location of the device to provide personalized services to its user. The stereotypical LBS application is to find the nearest pizza outlet when a stranger is in town, but other such services include hotel vacancies, turn-by-turn in-car navigation systems (often with voice features), traffic congestion avoidance, targeted advertising (e.g. alerts about specials when passing near an outlet), proximity payment systems (e.g. for road toll fees), and finding lost persons (such as one's child).

20. Some countries require their mobile telephone operators to support LBS for enhanced 911 telephone calls, to enable emergency services to respond to calls from a mobile telephone, even if the callers do not know their location or get cut off before they can provide their address (Federal Communications Commission 2009). Similarly, such LBS support also enables reverse 911 calls to mobile telephones, whereby authorities can send alerts about a hazard to people in a specific area (PlantCML 2009).

21. LBS also includes services related to a remote device being tracked, such as for providing real-time estimates of bus arrivals for display panels at bus stops, managing vehicle fleets, routing emergency vehicles, tracking containers or parcels during shipment, or tracking animals for conservation.

22. LBS needs highly accurate geoinformation that can be obtained primarily from high-resolution orthorectified satellite imagery and aerial photography using new map-building technologies, and that is then verified by field teams using GPS. It can provide data on transportation networks (including minor roads and streets), street furniture (e.g. traffic lights), and points of interest (e.g. retail outlets and tourist sites). Unfortunately, the data capture is very expensive, although it is feasible for the private sector to fund it because of the

sheer size of the LBS market for high-volume, low-cost services (Wilkinson & Sundelowitz 2007). These data sets also help to promote tourism (by making destinations known and accessible) and to spawn other applications. Through public-private partnerships, these data sets can also be exploited by governments to improve their service delivery.

2.5. Business geographics

23. As mentioned above, the key for business geographics is being able to combine different data sets. This applies particularly to a company's customer and operational data. While some applications of business geographics have been mentioned above, others include:

- **Customer relationship management** : Geoinformation can contribute to various aspects of Customer relationship management, such as customer segmentation (using demographic data), target marketing (based on outlet location and special offers or events), sales territory management, and market penetration analysis. Geoinformation is also critical for cleaning up and managing customer data;

- **Insurance**: Assessing and managing risk is critical for insurance companies, particularly given the current economic climate and changing consumer behaviour. Examples of how geoinformation can help insurers include precision underwriting; identifying and avoiding accumulation of risk (e.g. overexposure to a single threat, such as a flood); compliance with regulations; identifying retail outlets for their products; detecting insurance fraud; and hazards modelling to understand the spatial distribution of all the risks they cover (e.g. crime: vulnerability to floods, droughts or fires) and accessibility to resources that can mitigate the hazard, such as fire stations (Boobier 2008). A South African insurer has also recently introduced motor insurance based on driving patterns, monitored through a tracking device placed in the insured's vehicle; and

- **Real estate**: Real estate agencies have been pioneers in incorporating multimedia into a GIS, to link photographs and video footage of properties for sale to properties in the GIS. They also incorporate data of property transactions in order to determine the value of properties more accurately for prospective sellers, and to help prospective buyers understand the inherent value of a particular neighbourhood that is embedded in the price of properties, and hence to understand which neighbourhoods fall within their price bracket.

2.6. User-generated content

24. Virtual globes provide a large volume of digital geoinformation over the Internet through geobrowsers. With markup languages such as the Keyhole Markup Language, geobrowsers can be customized to provide personalized geoinformation over the virtual globe, attach content (e.g. photographs, video or sound recordings) to locations in the virtual globe, or share geoinformation or content. As well as promoting the awareness of geoinformation, virtual globes and geobrowsers have facilitated the production of user-generated content (also known in this context as "volunteered geographic information") and open data archives. They have also facilitated "folksonomy" or "collaborative tagging",

which is the classification and identification of content by the general public, rather than by domain experts, and which is often linked to virtual social networks. Obviously, all this poses a threat to those who try to restrict access to information or to those who do not understand the impact of this democratization of information on their business models.

25. Virtual globes tend to lack adequate metadata describing their geoinformation, and/or do not present the metadata readily to users. The result is that many users do not understand the limitations on the data in the virtual globe. For example, many users think that the virtual globes display real-time satellite imagery or interpret areas with lower-resolution imagery as having been censored. The quality of user-generated content can also be uncertain because of the lack of metadata and because the content does not come from an authoritative source. Typical errors are geocoding content with incorrect locations (even putting the content on the wrong continent!) and identifying the content incorrectly. Similarly, folksonomies can be unreliable or reflect a narrow view of the world. To some extent, it is possible to identify providers of user-generated content and folksonomies and hence gauge how reliable specific contributors are and hence, whether or not to use their contributions. Indeed, based on the personal experiences of the author, even professionals with regular exposure to geoinformation, but without formal training in geographical information science, can fail to understand the value of metadata or the implications of the quality limitations of a specific data set.

26. One concern is that legislators and other decision makers not well grounded in the theory and practice of geoinformation might base legislation and the implementation of such legislation on faulty data. For example, Zandbergen & Hart [2009] have found that there can be substantive errors in geocoding addresses when determining residency restrictions for sex offenders.

27. Hence, virtual globes, geobrowsers, user-generated content and folksonomies represent both threats to the status quo and opportunities for innovative applications exploiting these new services and sources of geoinformation, and for other information services and sources, such as “crowdsourcing”, which Google, for example, is using to map African cities [Gosier 2008]. These opportunities are also facilitated by the availability of micropayment systems on the Internet, allowing innovative entrepreneurs to provide low-cost services and data to many consumers.

3. Intellectual property rights, standards and curation

3.1. Intellectual property rights

28. Referring to innovation and economic growth, paragraph 22 of the CODIST-1 Concept Note (UNECA 2009a) highlights how patent law has been changing recently to increase the powers of patent holders and to extend patent rights into fields such as software. Unfortunately, it is very expensive to contest patents and it appears that some organizations are using them as a trade barrier. Stallman [2009a] suggests that “programmers are well aware that many of the software patents cover laughably obvious ideas”, and proceeds to dissect a software patent he considers to be trivial and for which he considers that there was prior art.

29. The original purpose of awarding patents was valid, but over the centuries the environment has changed and, given the extent to which patents are abused now, the patent system needs a radical overhaul. Africa needs to organize itself and to take the lead on this, because it is the most disadvantaged continent when it comes to patents.

30. While both paragraphs 22 and 32 of the CODIST-1 Concept Note (UNECA 2009a) refer to intellectual property rights, they actually deal only with patents and ignore the other legal mechanisms for protecting intellectual property, such as copyright, trademarks and designs. Stallman (2009b) considers it inappropriate to lump them all under the label "intellectual property", which he considers to be a "distorting and confusing term that did not arise by accident", because it tries to make them analogous to property rights for physical objects. There are significant differences between patents, copyright, trademarks and designs, which are blurred by giving them a collective label such as "intellectual property rights".

3.2. Standards

31. Standards are key for the enabling environment for innovation, as they embed current good practices and make them readily available at a low cost. They promote competition and facilitate interoperability. A German study showed that there was much more value for the German economy if German companies invested in standards and standards development, rather than in patents (DIN 1999). This would allow them to gain early access to current technologies and thinking, assert their interests in the standardization process, and lower their economic risks and research and development costs.

32. Spatial data standards are essential for the development of spatial data infrastructure and promoting cross-border collaboration (e.g. for disaster management), but standards in general are essential for building other forms of information infrastructure and collaboration, and providing access to markets. In paragraph 21 of the CODIST-1 Concept Note (UNECA 2009a), for example, standards are mentioned, but only as part of the geospatial data infrastructure. However, standards are essential for centres of excellence (paragraphs 17, 18 and 21 of the Concept Note) and should also be included in education and training for science and technology.

33. Africans should not just be passive recipients of standards from other parts of the world. They need to play active roles in planning and developing standards, to ensure that the standards satisfy African conditions and needs. Local standards need massive investment to support their implementation, because of the small local market available to support them. However, international system vendors tend to implement international standards, because of the size of the global market. Countries can still participate in international standards development via email and through international organizations if they are not members of an international standards body such as the International Organization for Standardization. For example, UNECA has a Class A Liaison to ISO/TC 211 on geographic information/geomatics, which gives African geoinformation professionals access to the organization (Cooper *et al* 2005).

3.3. Digital curation

34. Neither paragraph 15 nor paragraph 16 of the CODIST-1 Concept Note (UNECA 2009a) makes reference to information archives, even though they constitute a critical

component of any infrastructure for the *enabling environment for innovation*. Many of these archives in Africa are still paper-based, which limits their accessibility. Currently, a national audit on digitization and preservation is being conducted in South Africa to identify collections of materials that should be digitized for their preservation and wider accessibility. In the author's opinion, key resources that should be digitized are:

- Issues of **African academic journals and books** that are not yet available digitally. Because they are not digital and not online, they cannot be listed by search engines such as Google Scholar, hence reducing the likelihood of African research being cited and used by other researchers, and diminishing the value of African research. Some of these journals contain valuable material but have become defunct, and hence probably have no "custodian" who can be motivated to put them online;

- Proceedings of **African conferences**. The situation of proceedings is even worse than that of journals, as many past proceedings were published without International Standard Book Numbers (ISBNs) and hence were not lodged in the relevant legal deposit libraries. It might even be difficult to find them in university or other libraries, and they might only exist in the private collections of professionals who attended the conferences. Hence, these conference proceedings could otherwise be lost forever;

- **Project reports and data sets** that are unlikely to form part of national archives but that are of broader interest or are of historical importance. Some could be made available to the public now, while some might need to be kept confidential for some years still;

- Collections of **photographs, films, videos and audio recordings**. These are more vulnerable to degradation than paper documents and are crucial records of oral histories; and

- **Tangible objects** of scientific or cultural value worth preserving, such as historic scientific equipment (including computers), cultural artefacts and original manuscripts.

35. It should be borne in mind that these archives need to be preserved and made accessible not only for the purposes of contemporary research, but also for historical research in the future.

36. Unfortunately, digital archives are far less robust than paper-based archives, such that digitizing them is a decidedly complex issue. It is probably wise to retain the analogue archives for the foreseeable future, while using the digital archives to provide easy access to the content. Insufficient attention is being paid to the preservation of digital archives. The key problems include rapid changes in hardware and software and data formats, and the volatile nature of digital data. There are many international and national standards and guidelines for digital archiving, but they come from various sources and their applicability can be difficult to understand. Schmitz & Cooper (2009) have developed a structured workflow for guiding staff through the steps for implementing digital archiving standards in an organization, from developing the file plan through to destroying redundant digital records.

4. Conclusions

37. Innovation does not come from organizations, but from individuals. This paper has given examples of how geoinformation can contribute to innovation and economic growth in Africa. It has also commented on selected paragraphs of the CODIST-1 Concept Note (UNECA 2009a), looking at issues such as intellectual property rights, standards and digital curation.

38. CODIST is essentially a political gathering or "alk shop", but it needs to enhance its status by leveraging its authority and networks to source funding for projects for the implementation of its recommendations. UNECA and CODIST also need to encourage African Governments to provide the legislative frameworks, policies and service delivery that foster innovation and hence economic growth.

Acknowledgements

I would like to thank UNECA for inviting me to present this discussion paper on behalf of the geoinformation community and for funding my participation in this conference. I am also grateful to the CSIR for allowing me to participate in CODIST activities.

I would like to thank Sives Govender of EIS-AFRICA for the very useful discussion we had on the content of this paper. I also found Wikipedia [Wikimedia Foundation, Inc. 2009] to have been a very useful resource for understanding some of the issues discussed in this paper.

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