Appraising Investments and Technologies for Surveying and Mapping for Land Administration in Sub-Saharan Africa

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Topics

- Importance and Challenges
- Appraisal
  - Geodetic Reference Networks
  - Large Scale Mapping
  - Cadastral Surveying/Mapping
- Unit Costs
  - CORS
  - Large scale mapping
  - Customary boundaries
  - Cadastral Surveying of individual parcels
- Conclusions

Importance and Challenges

- Investments in surveying and mapping in SSA are not being adequately appraised
- Examples of the consequence of this:
  - high accuracy cadastral surveys specified for low value rural lands
  - cadastral and registration systems that are incomplete
  - unsuccessful attempts to produce and maintain country-wide medium- to small-scale topographic mapping series
  - CORS networks established in an unsustainable manner
- Factors that contribute to this:
  - Survey and mapping viewed as part of land registration
  - Survey and mapping undertaken for purposes other than LA
  - Technical staff have bias towards high precision, high technology
  - Push by technology and vendors
  - Professional associations with political influence to proscribe accuracies
- Even where there is the political will to appraise technology there is a lack of tools to do so

Importance and Challenges

- Factors important in deciding on spatial framework:
  - Social practices and legal requirements
  - Topography, land cover and climatic conditions
  - Rapidly evolving technology
  - The influence of technical staff and professional associations
  - Wider application of spatial technology (e.g. SDI)
- In Africa there is also:
  - Typical duality in LA systems
  - Limited resources and capacity
  - Strong vested interests
- Challenges in adopting technology
  - **GRN** – shift to GNSS, awareness campaigns, maintenance, ICT infrastructure, policy on access to data
  - **Large scale base mapping** – shift from line mapping to image mapping, need for professionals, digitisation of existing maps, sharing of data and policies for NSDI, prioritisation of mapping efforts
  - **Cadastral surveying** – accuracy and precision, priorities (balancing speed, cost precision), place of cadastral data in NSDI

Appraisal: GRN

- Most important choices are technology, location and level of densification
- Technology options:
  - Continued maintenance of traditional GRN
  - GNSS CORS with communication for RTK
  - GNSS with data available for post-processing
  - Non-GNSS systems (e.g. ELS, GNSS base/rover)
- Emerging best practice is GNSS CORS incorporating non-GNSS positioning
- In SSA best practice is gravitating towards a limited number of GNSS CORS and incremental expansion with CORS and/or passive or ad hoc GNSS stations
- Cost of GRN investment and operations straight forward, but identifying and attaching value to benefits more challenging
- Key value of GRN is ability to integrate different data sets through common geo-referencing system
- Common approach is through estimation of avoided costs

Appraisal: Large-Scale Mapping

- As for GRN, estimation of costs straight forward, but more difficult to estimate benefits
- Two types of benefits
  - Efficiency benefits through avoided costs or cost savings
  - Effectiveness benefits, or value-adding benefits
- Both very difficult to quantify – at greater aggregate levels have been estimated with sophisticated equilibrium models in UK, Australia and NZ
- For base mapping the key technical choices are: scale, coverage, line mapping/orthophotomapping, series/production approach
- In SSA for large scale base mapping ortho-rectified imagery is the preferred approach – choice is aerial photography or HRSI

Appraisal: Cadastral Survey/Mapping

- Cadastral surveying provides the spatial framework for registering/recording land rights
- Can be difficult to isolate the benefits of cadastral surveying – Ethiopia, where rights issued without a spatial framework, WTP study in 2006 estimated benefits to be ~$1.4/parcel
- Generally cost-benefit analysis of registration has not undertaken a CEA of surveying/mapping options

	Cost (US$)		Survey Time/Speed (hours:minutes)	
	Per parcel	Per ha	Per parcel	Per ha
Hand-held GPS	4.98	9.27	00:19	00:34
Rope only	0.81	1.50	00:15	00:28
Rope and hand-held GPS	0.97	1.81	00:17	00:30
Tape and Compass	18.18	33.66	01:34	02:53
Tape and Compass and HHGPS	18.29	33.80	01:36	03:00
Total Stations	7.27	13.54	00:23	00:44
IKONOS Satellite imagery	14.23	26.52	00:17	00:31

Unit Costs: CORS

Geodetic Referencing

Country	Number of CORS stations	Year	Investment cost (US$)	Unit cost (US$)
Serbia	34	2004	1,244,000	36,586
Turkey	145	2007-2009	4,200,000	29,099
FYR Macedonia	14	2007	615,595	43,971
Ghana	5	2007	164,160	32,832
Tanzania	2	2009	NA	30,000
Ethiopia	1	2003	NA	36,500

Typology of CORS Networks

Type of CORS Network	DGPS	Smoothed DGPS	PDGPS
Accuracy	1 – 3 m	Appr. 0.5 m	1 – 2 cm
Observations	L1 code	L1 code, L1 carrier phase for smoothing only	L1 code, L1/L2 carrier phase for positioning
Reference stations spacing	Appr. 500 km	Appr. 300 km	20 – 50 km
Real time/post-processing	Real time	Real time (and post-processed)	Both
Correction generation	Pseudo-ranges	Pseudo-ranges or static space	Static space and all measurements
Transmission media, real time	Radio, wireless	Communication satellites, wireless	Mobile phones, wireless, ntrip (internet)
Transmission media, post-processing	Not available	ftp, email	Web-portal, ftp, email, fixed-line phone

Unit Costs – Large Scale Mapping

Source of Large Scale Base Map	Image Scale /Resolution	Unit Costs (US$/km^2)			
		Europe	Ghana	Tanzania	Ethiopia
Satellite imagery; ortho-rectified; (new; at least 30 km^2)	GeoEye 0.5 m	30	30	30	30
Aerial photography (250 km^2)	1:45,000 (50 cm pixel)	31.5	150	NA	NA
Line mapping (analogue method)	1:2,000	1643	NA	NA	NA

Customary Boundaries

Country	Description of lands	Ecological Description of Area	Method of survey	Cost/km
Ghana	Customary land administered by Traditional Authorities	Many areas with dense vegetation	Fixed boundary survey (mainly use of GPS/Total Stations	500-700
Tanzania	Village land administered by Village Councils	Few areas with dense vegetation	Fixed boundary survey (mainly use of GPS)	20-50
Mozambique (unit costs are per community)	Community land administered by communities	Considerable resources in organizing communities	General boundary survey (Sketch map)	2,000-10,000

Cadastral Surveying

Cadastral Surveying – Individual Parcels

Country	Cost/parcel (US$)
Ethiopia	1
Rwanda - rural	9-11
Rwanda - urban	9-10
Namibia	11
Madagascar	7-28
Tanzania	45
Uganda	40
Ghana	45
Cote d'Ivoire	7-10

- International experience comparable:
  - Kyrgyzstan, urban project in Peru ~$2/parcel
  - Armenia ~$5/parcel
  - Thailand, El Salvador ~$10/parcel
  - Moldova and rural project in Peru ~$20/parcel
- Cadastral survey without GRN $2-5/parcel, with GRN $5-10/parcel

Conclusions

- While CBA is limited due to the difficulty in costing benefits, technical appraisal and CEA can be applied
- Cost norms provide a reference for technical appraisal
- To promote technology and investment appraisal, a number of actions are needed:
  - Raising awareness about the lack of culture to appraise technology and investments while highlighting the benefits to society of appraising investments
  - Persuading professionals and decision makers in survey and mapping agencies that appraisal of investments can be done without jeopardizing security interests
  - Encouraging African governments and their development partners to increase staffing and training of social scientists in survey and mapping agencies; and
  - Introducing in survey and mapping agencies incentives and systems for collecting cost and benefit data and undertaking cost benefit analysis.