Implementation of GPS CORS for Cadastral Survey and Mapping in Indonesia: Status, Constraints and Opportunities

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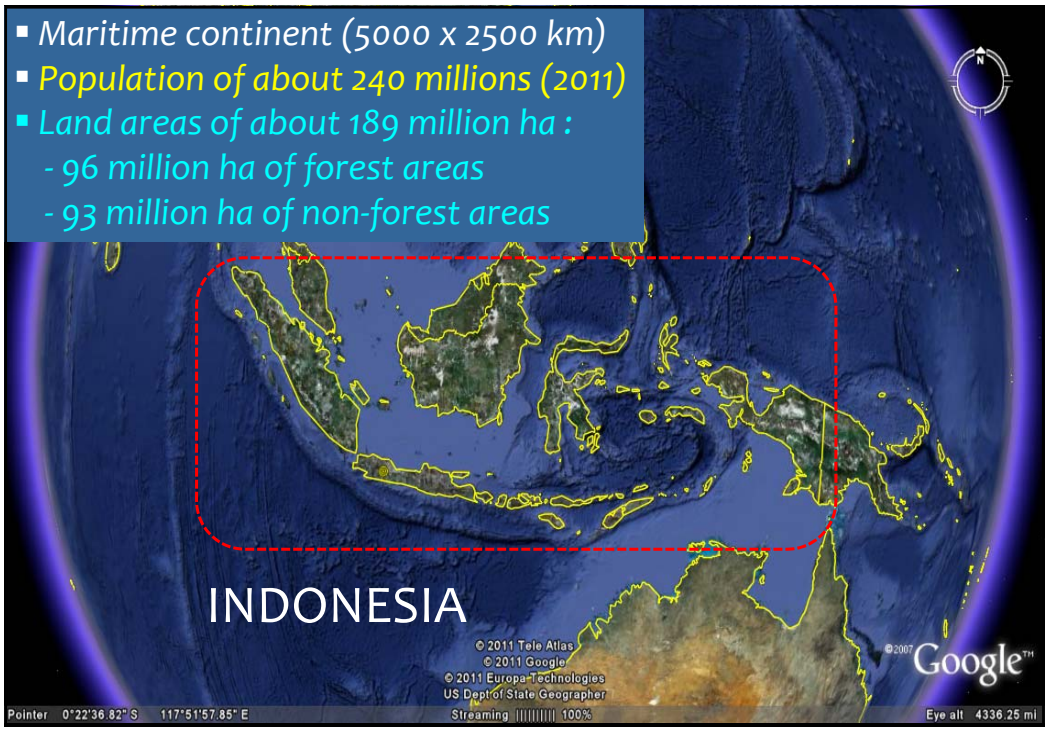
Institut Teknologi Bandung

- *Maritime continent (5000 x 2500 km)*
- *Population of about 240 millions (2011)*
- *Land areas of about 189 million ha :*
  - *96 million ha of forest areas*
  - *93 million ha of non-forest areas*



Cadastral Survey & Mapping in Indonesia

- Basically started in a more systematic manner since 1960.
- Up to 1994, the terrestrial based measurement techniques were used.
- The coordinates of parcel boundaries were given in local coordinate systems of their own.
- The problems started to surface when the parcel boundaries were plotted in a single cadastral basic map of the area.
- Many parcels were overlapped between each other and sometimes gaps between parcels were also existed.
- In turn, this technical problem generated several legal problems which then delayed the whole land administration process in the corresponding areas.
- Since 1994 GPS static survey method has been used in establishment of the National Cadastral Reference Network (NCRN).
- Sin 2009, GPS CORS program is started.

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Status of Land Parcel Registration in Indonesia

Region	Population (2010)	Estimated number of land parcel (2010)	Number of certificated land parcel (2008)	% of certificated parcel (2008)
Sumatera	50,630,931	18,614,313	6,937,884	37.3
Java	136,610,590	50,224,482	23,916,371	47.6
Bali & Nusa Tenggara	13,074,796	4,806,910	2,491,899	51.8
Kalimantan	13,787,831	5,069,056	2,662,182	52.5
Sulawesi	17,371,782	6,386,685	2,553,690	40.0
Maluku & Papua	6,165,396	2,266,690	461,465	20.4
Total	**237,641,326**	**87,368,135**	**39,023,491**	**44.7**

Number of family

Estimated number of land parcel = (Population / 3.4) x 1.25

In 2008, land parcels that have payed the fiscal tax is about 85.8 million parcels

Sources: BPN and BPS

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YEARLY NUMBER OF ISSUED LAND PARCEL CERTIFICATES IN INDONESIA (2001-2008)

Year	Sumatera	Java	Kalimantan	Bali & Nusa Tenggara	Sulawesi	Maluku & Papua	Indonesia
2001	234.856	751.709	58.193	121.532	83.343	4.109	1.253.742
2002	273.379	742.518	68.755	148.873	57.749	4.520	1.295.794
2003	256.765	672.509	70.696	121.116	57.322	4.972	1.183.380
2004	202.005	662.294	56.193	143.592	98.036	2.035	1.164.155
2005	185.914	571.201	53.361	54.762	42.345	11.736	919.319
2006	186.736	887.278	89.461	94.688	71.348	16.298	1.345.809
2007	373.544	1.764.063	108.355	239.167	179.932	26.106	2.691.167
2008	654.992	1.779.295	314.246	223.478	48.815	11.595	3.032.421

Region	1960 - 2000
Sumatera	4,569,693
Jawa	16,085,504
Kalimantan	1,842,922
Bali-Nusa Tenggara	1,344,691
Sulawesi	1,914,800
Maluku-Papua	380,094
Indonesia	26,137,704

NUMBER OF ISSUED LAND PARCEL CERTIFICATES IN INDONESIA (1960-2000)

Rate : ± 650,000/year

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In order to speed up the land registration process in Indonesia:

- ***Since 1994,***
  GPS static survey method is implemented
- ***Since 2009,***
  GPS CORS is initiated

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GPS for Cadastral Surveys in Indonesia

(1) establishment of the cadastral control network,

(2) determination of parcel boundary coordinates, and

(3) reconstruction of parcel bounday points.

Although **GPS CORS** are starting to be established, GPS is usually implemented in **GPS survey static** or in a **single station GPS RTK** modes.

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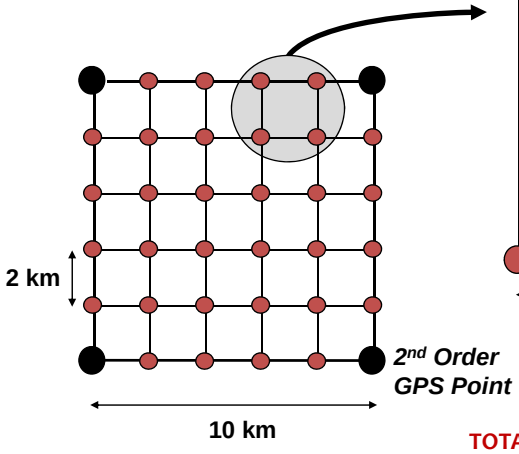
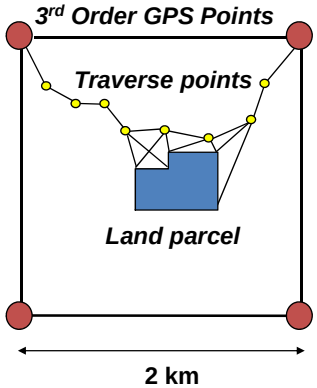
National Cadastral Reference Networks (NCRNs)

- Established and maintained by BPN
- Connected to 0th and 1st order NGRN





TOTAL

2nd Order : 9,000
3rd Order : 200,000 (2km)
900,000 (1 km)

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Estimated number of 2nd and 3rd order NCRN GPS stations in land non-forest areas of Indonesia

Region	2nd order	3rd order
Sumatera	2,800	61,511
Java	1,270	25,753
Bali and Nusa Tenggara	473	11,295
Kalimantan	2,075	43,095
Sulawesi	901	17,117
Maluku and Papua	1,900	39,262
Total	**9,419**	**198,033**

The 2nd and 3rd order NCRN is connected directly or indirectly to the 0th and 1st order National Geodetic Reference Networks (NGRN) that is established and maintained by BIG.

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Realization of NCRNs

- **2nd Order :**
  - 10 km interval
  - 9,000 GPS points
  - Realization up to 2010 : 70% (6,699 points)
- **3rd Order:**
  - 2 km interval
  - 200,000 GPS points
  - Realization up to 2010 : 7% (14,085 points)

GPS CORS System is urgently needed to speed up land registration process in Indonesia

Up to 2011, from about 87 million land parcels in Indonesia, only about 45% has been registered.

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GPS CORS In Indonesia (2012)

- **Government Agencies**
  - → BIG (Bakosurtanal) CORS : 101 stations
  - → GITEWS : 18 stations
  - → LIPI CORS (SUGAR network) : 32 stations
  - → 75 BPN CORS : 75 stations

  for cadastral purposes
- **University**
  - → ITB : 5 stations
  - → UGM : 1 station
  - → ITS : 1 station
- **Private Sector**

In total about 230 CORS stations

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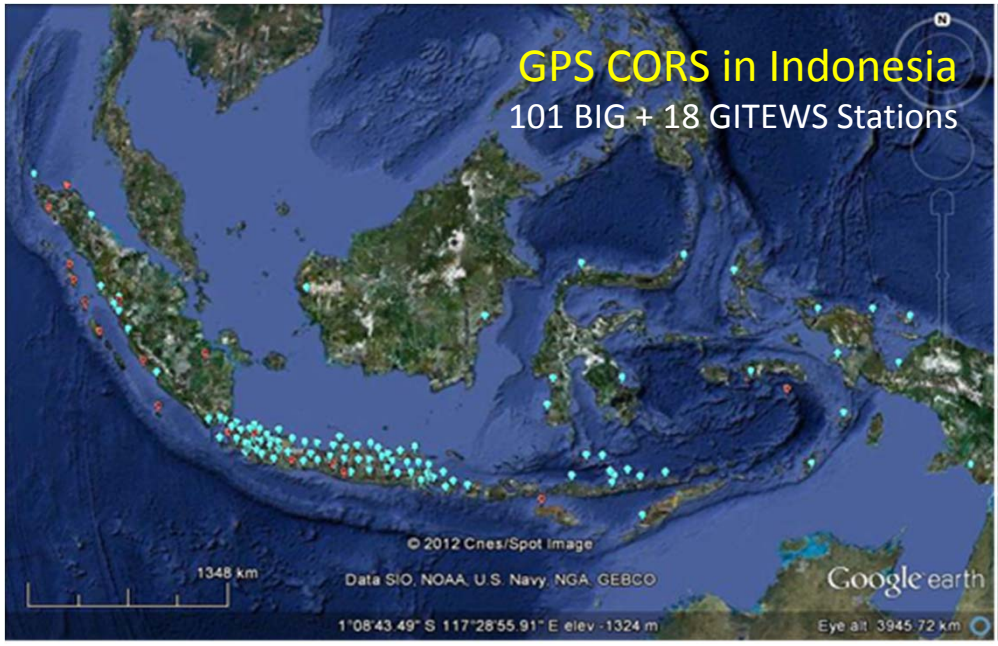
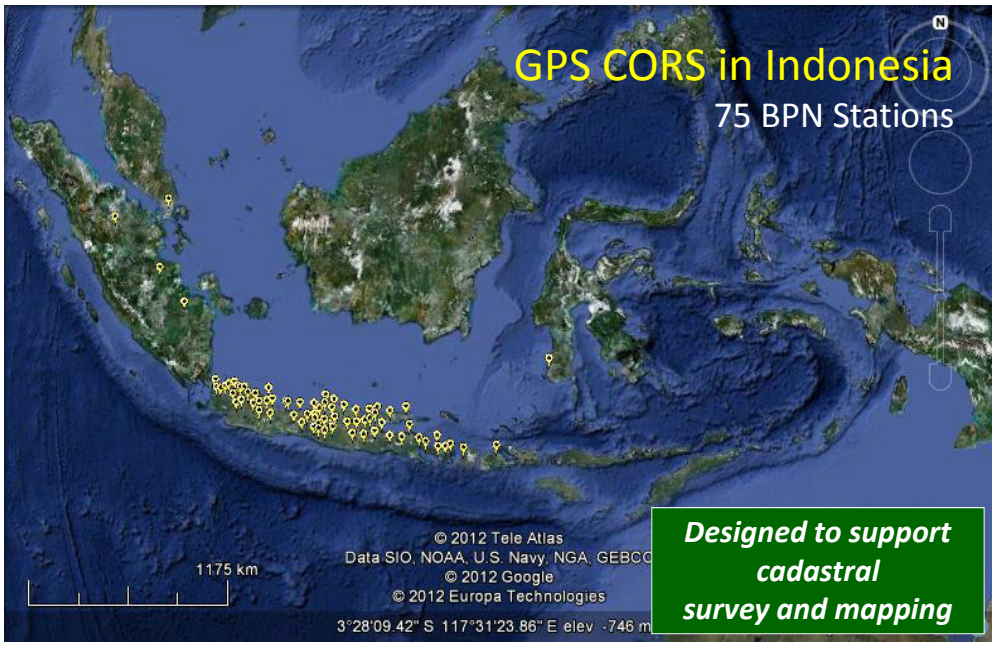
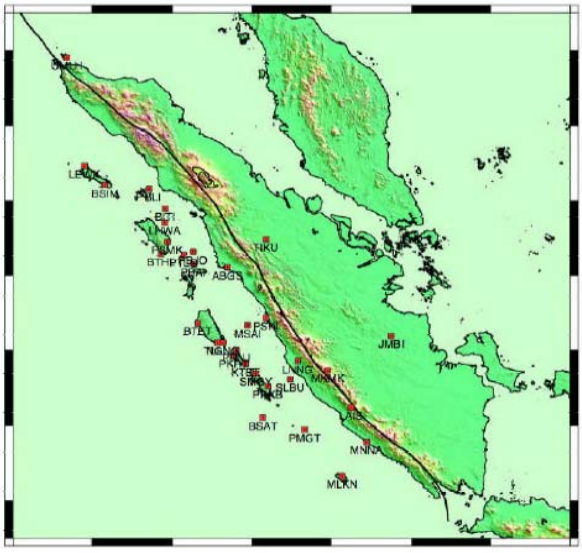


Hasanuddin Z. Abidin (20102)



Hasanuddin Z. Abidin (20102)

GPS CORS of LIPI (SUGAR Network)



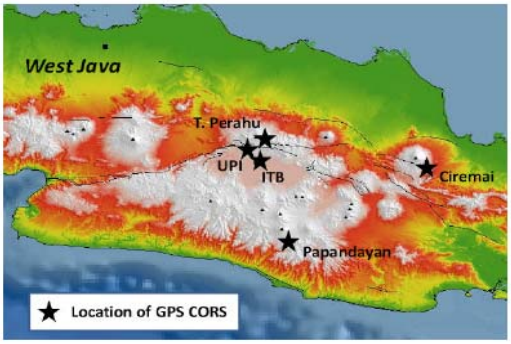
Station: ABGS

Station: NGNG

Photos from *Caltech DGPS* (2010)

Abidin et al. (2010)

GPS CORS managed by Geodesy ITB



In cooperation with
GSI Japan, ERI University of Tokyo,
and Bakosurtanal.

- At present : 5 GPS CORS stations as shown in the Figure.
- The main aim of this CORS network is to study the inter-seismic deformation of active faults in West Java, e.g. Cimandiri, Lembang and Baribis faults

Abidin et al. (2010)

Existing and Potential Applications of GPS CORS in Indonesia

Utilization and Function of GPS CORS	
REAL-TIME MODE	**POST-PROCESSING MODE**
Early warning system for various natural hazards in Indonesia.	The coordinate reference frame for various positioning, surveying and mapping applications in Indonesia.
The Network-RTK system for surveying and mapping applications.	The coordinate reference frame for monitoring and studying natural hazard phenomena in Indonesia
The reference stations for supporting various navigation and transportation applications (land, marine, air).	The monitoring network for geodynamics and tectonic studies in Indonesian region.
Integration, checking and validation for various coordination reference systems	Studying and mapping the characteristics of troposphere and ionosphere above Indonesian territory.

The existence of GPS CORS networks will be very useful for Indonesia, a vast archipelago consisting of about 17.500 islands and has population of more than 240 millions.

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GPS CORS for Cadastral Survey and Mapping in Indonesia:

Challenges & Limitations

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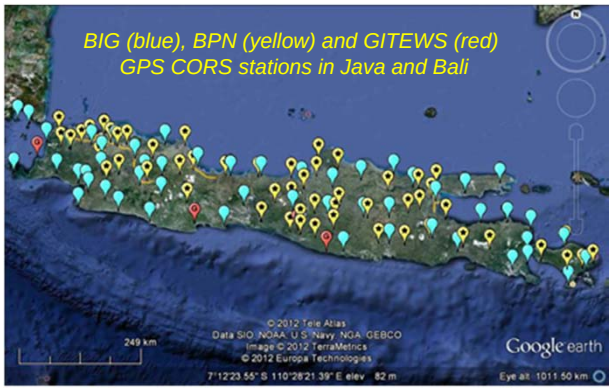
Challenges & Limitations

(1) The cadastral survey and mapping in Indonesia should not be supported only by the BPN GPS CORS, but preferably also by other national GPS CORS especially the BIG GPS CORS.

Integration issues of CORS network

- **financial sharing arrangement.**
- **standardized and synchronized system operation and maintenance.**



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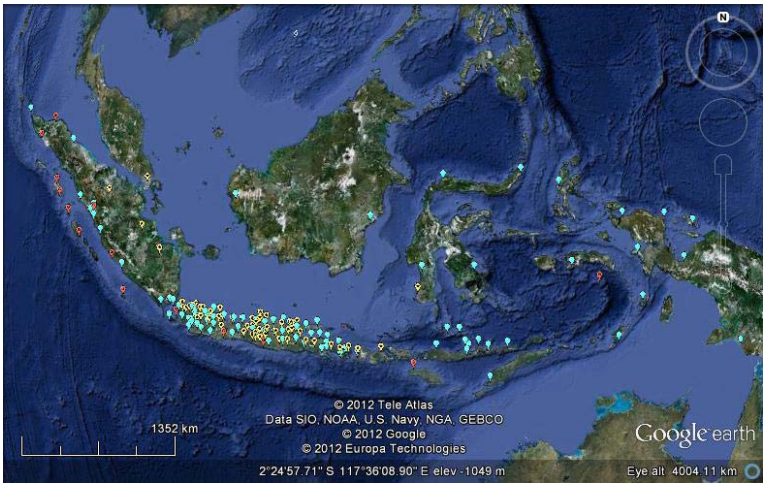
Challenges & Limitations

(2) Spatial coverage of GPS CORS networks that supports cadastral survey and mapping in Indonesia should be optimized

Critical Issues:

- ***Political will***
- ***Budget***
- ***Human Resources***



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Challenges & Limitations

3. Communication Link and Infrastructure
4. Continuous Support for Maintenance and Operation
5. Working Culture & Human Resources
6. Capacity Building and Human Resource Development
7. Multi Purpose Utilization of GPS CORS Networks

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Challenges & Limitations

8. Typical topography and land coverage around land parcel boundaries in Indonesia, will not always allow for good GPS observation directly at the parcel boundary points.

Typical land coverage of urban and rural areas in Indonesia

Alternative Solution:

- ***Use of GPS/ETS system as the rover unit.***
- ***Use of measuring tapes in trilateration mode as backup.***

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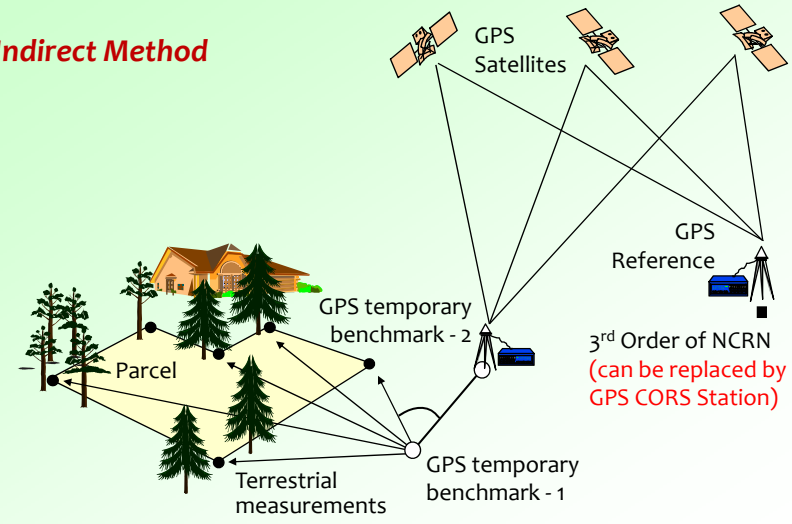
Determination of Parcel Boundary Coordinates

Indirect Method



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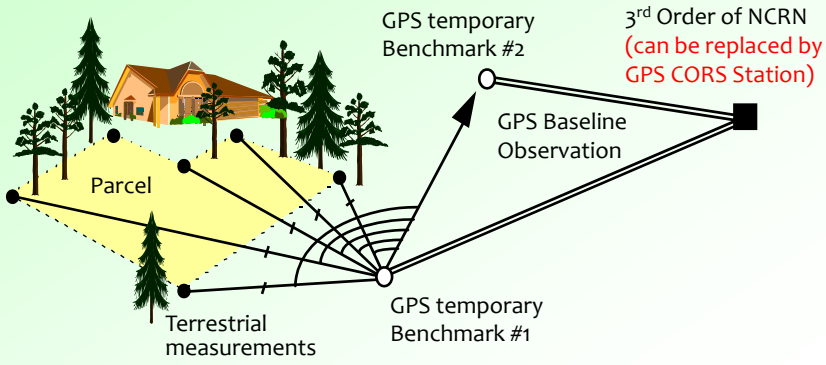
Reconstruction of Parcel Bounday Points

Indirect Method



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Challenges & Limitations

9. Due to the heterogenity in data communication quality and coverage, and the wide spectrum of topography and land coverage in Indonesia; it was found that the spatial and temporal variation in achievable accuracy of real-time coordinates is exist.

Method	Urban Areas (distance to NCRN benchmark < 5 km)		Rural Areas (distance to NCRN benchmark < 13 km)	
	Parcels per day	Relative Accuracy	Parcels per day	Relative Accuracy
CORS-RTK	30	1-5 cm	20	10-20 cm
GPS rapid static	5	1-5 cm	5	1-5 cm
GPS rapid static + ETS measurement	6	1-5 cm	6	1-5 cm

Results of Determination of Parcel Boundary Coordinates

from test cases in Jakarta and Bali involving 40 land parcels with areas less than 10,000 m²

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GPS CORS for Cadastral Survey and Mapping in Indonesia:

Opportunities

Status of Cadastral Mapping in Indonesia (2008 Status)

Region	Non-forest area (ha)	Mapped (cadastral) area (ha)	% of mapped area
Sumatera	33.196.259	3.254.673	6,85
Java	10.923.034	2.852.905	21,50
Bali-NusaTenggara	5.195.391	651.324	9,08
Kalimantan	23.995.628	1.562.350	2,92
Sulawesi	10.429.888	1.084.665	5,82
Papua-Maluku	9.191.206	85.500	0,21
Indonesia	**92.931.407**	**9.491.417**	**10,21**

- about 55% land parcels still to be certificated (e.g. about 48 million parcels)
- about 90% area still to be mapped (e.g. about 83 million ha)
- the opportunity for BPN GPS CORS is enormous.
- the acceleration of this land registration and mapping process can be speed up by using BPN GPS CORS networks all over Indonesia.

MASTERPLAN ACCELERATION AND EXPANSION OF INDONESIA ECONOMIC DEVELOPMENT 2011-2025 (MP3EI Program)

1. Improving regional economic potential through the development of Six Economic Corridors
2. Strengthening National Connectivity
3. Strengthening human resources and national science and technology capabilities

- *Complete and detail geospatial data and information will be needed for all over Indonesia.*
- *Land registration process should be speed up.*

Contribution of GNSS CORS is important !

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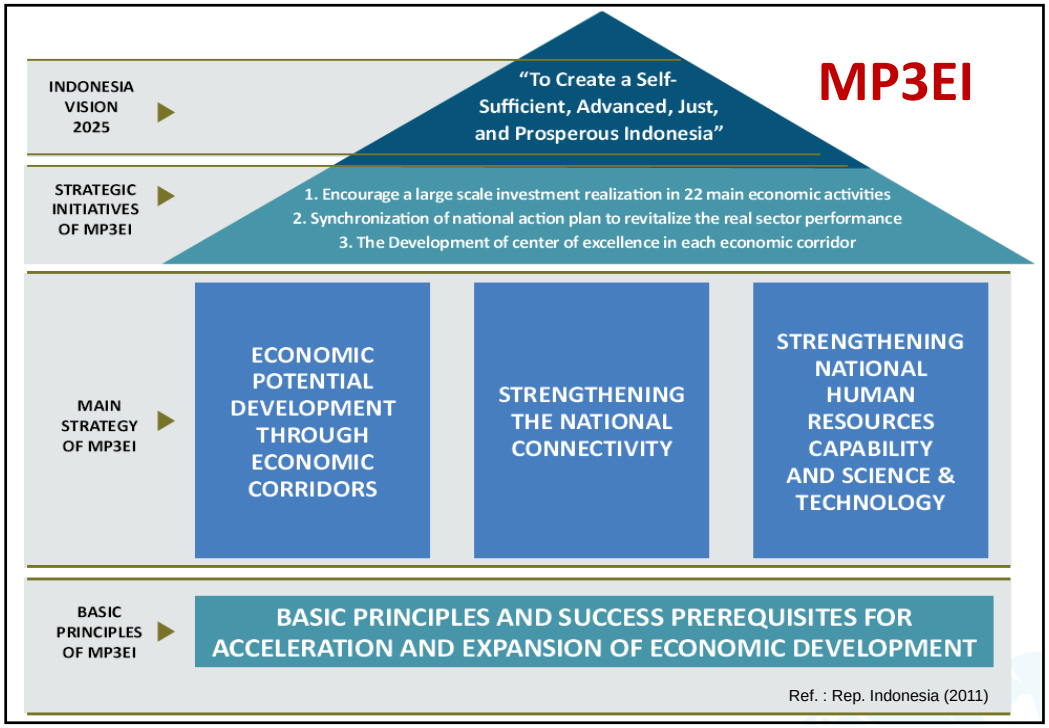
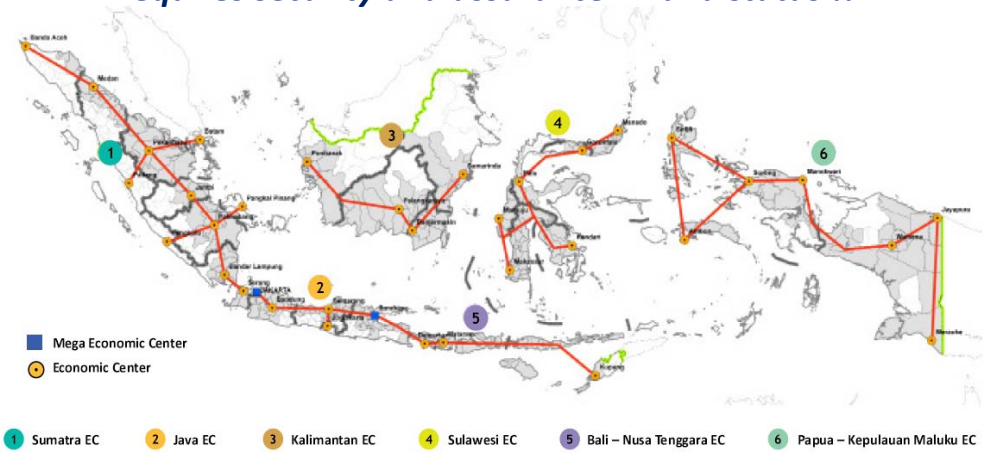


6 Economic Corridors of Indonesia

Economic development and investment requires security and assurance in land status !!



Ref. : Rep. Indonesia (2011)

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Closing Remarks

1. There are several challenges and limitations for realization of reliable BPN GPS CORS network.
2. Its future and opportunities however are also very promising.
3. With other satellite systems (i.e. Glonass, Galileo, and Compass) are maturing, it can be expected that the performance of BPN GNSS CORS network will also significantly increase.
4. If professionally managed, BPN GNSS CORS can generate a substantial amount of revenue for BPN and also cadastral private sector.

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GPS = Great Places to Smoke