Implementation Plan Table of Contents

1. Executive Summary (1 page)

This section will appear in the main GEO Work Programme document presented to GEO Plenary.

- **Full title of the Community Activity.** Global Mangrove Monitoring

- **Short title or acronym (all capital letters, maximum of 20 characters).** GMM

- **Proposed or existing category (i.e. Community Activity).** Community Activity

- **Overview (summary of section 2 below).**

Mangrove forests provide important ecosystem goods and services to the world's dense coastal population and support important biosphere functions. Deforestation and degradation of mangrove forests can lead to the reduction of important ecosystem goods and services and impair critical biosphere functions (e.g. coastal protection, carbon sequestration and biodiversity conservation) at both local and global scales. However, the forests are under threat from both natural and anthropogenic forces, thus threatening the resilience and vitality of global coastal social-ecological systems.

Despite the importance of mangrove forests, reliable, accurate, and timely information on mangrove forests cover change of the world is not available. Remote Sensing could play an important role in providing this information. Recent advancement in remote sensing data availability, image-processing methodologies, computing and information technology, and human resources development have provided an opportunity to observe and monitor mangroves from local to global scales on a regular basis. Spectral and spatial resolution of remote sensing data and their availability has improved making it possible to observe and monitor mangroves with unprecedented spatial and thematic detail. Novel remote sensing platforms such as unmanned aerial vehicles, and emerging sensors such as Fourier transform infrared spectroscopy and Lidar can now be used for mangrove monitoring. Furthermore, it is now possible to store and analyze large volume of data using cloud computing.

- Planned activities (summary of section 4 below).

The following major activities are planned:

- To complete global mangrove mapping for the year 2020
- To complete change analysis of 2000 and 2010
- Identify causes and consequences of mangrove forest cover change from 2000 to 2020
- Capacity building

- Points of Contact (primary contact persons for the Community Activity and their email addresses). Chandra Giri, giri.chandra@epa.gov

2. Purpose (1 page)

- Rationale (i.e. evidence of need) for the Community Activity.

Mangrove forests are highly productive ecosystems sequestering more carbon per unit area than any other tropical systems (Donato et al. 2011; Mcleod et al. 2011). They have a mean whole-ecosystem carbon stock of 956 t C ha^{-1}, compared with 241 t C ha^{-1} for tropical rain forests, 408 t C ha^{-1} for peat swamps, 593 t C ha^{-1} for salt marshes, and 142.2 t C ha^{-1} for seagrasses. The soil carbon constitutes ~75% of the carbon pool. Although mangroves occupy less than 1% of the global coastal area, they contribute 10–15% (24 Tg C y^{-1}) to coastal (Mcleod et al. 2011) sediment carbon storage and export 10–11% of the particulate terrestrial carbon to the ocean. According to the best available estimate, 0.15–1.02 Pg (billion tons) of carbon dioxide are being released annually, resulting in economic damages of $US 6–42 billion annually (Pendleton et al. 2012). Their disproportionate contribution to carbon sequestration is now perceived as a means for conservation and restoration to help ameliorate greenhouse gas emissions (adaptation) and enhance the delivery of other ecosystems goods and services (Duarte et al. 2013). However, uncertainty in the estimation of deforestation, forest degradation, and carbon stock change in the mangrove forests is very high (Mcleod et al. 2011).

- **Actual and/or planned outputs of the Community Activity (i.e. data sets, open methods, information products or services, or other openly available results intended for external users) and their geographical scope.**

Planned outputs of the community activity:

1. Global mangrove database of 2020
2. Global mangrove change database from 2000-2020
3. New and innovative methodology for mangrove mapping and monitoring using cloud computing and data mining techniques

- **Actual and/or intended users of the outputs and the expected types of decisions these outputs are expected to inform.**

Users will come from governments and non-governmental organizations and academic and scientific communities. National governments can use this data for resources planning and management.

4. Background and Previous Achievements (½ page) optional

Previous Achievements:

- Secured funding for annual mangrove monitoring in South Asia and preliminary classification of South Asia completed
- Secured funding from USGS to perform global mangrove mapping and monitoring
- Mangrove mapping of the Pine Islands in Bahamas **completed**

- Mangrove monitoring of Puerto Rico started
- Monitoring of mangrove forests of Continental United States from 1980 to 2015 completed – **Paper published**
- Global annual mangrove monitoring began

4. Key Activities (1 page)

・ Summary of key planned tasks to be undertaken by the Community Activity during the 2020-2022 period.

1. Pre-processing of satellite data (e.g. Landsat, Sentinel) for mangrove forest mapping
2. Classification of satellite data for mangrove and non-mangrove classification
3. Prepare a comprehensive database of mangrove forest of the world for the year 2020
4. Perform change analysis from 2000 to 2020 to identify rates, causes, and consequences of mangrove forests of the world
5. Capacity building to scientists from developing countries through trainings and workshops.

5. Relationship to GEO Engagement Priorities and to other Work Programme Activities (½ page)

Optional

The mangrove database will serve as a baseline database for a number of GEO engagement priorities and to other work programme activities. For example this most comprehensive and highest resolution data is needed for

- SDG 6 "Clean Water and Sanitation"
- SDG 11 "Sustainable Cities and Communities"
- SDG 13 "Climate Action"; and
- SDG 15 "Life on Land"

In particular the database will be useful for greenhouse gas monitoring, global carbon accounting, biodiversity assessment, and disaster reduction.

6. Governance (½ page)

Chandra Giri will lead this task. Dr. Zhiliang Zhu will be co-leading the task.

7. Data Policy (½ page)

The data will be freely available through multiple websites.

Annexes (additional annexes may be added as required)

Chandra Giri, Ph. D.

Dr. Giri's research focuses on the mapping and monitoring of mangrove forests from local to global scales using multi-resolution, multi-temporal, and multi-spectral earth observation satellite data. The aim is to identify the rates, patterns, causes, and consequences of both natural and human-induced mangrove forest cover change. Dr. Giri has extensive experience managing large, multidisciplinary projects, including the NASA-funded project, "Global mangrove mapping and monitoring." He has worked on mapping and monitoring of land cover and land cover change since 1993. His ongoing research includes a collaborative pilot project on annual mangrove monitoring, carbon stock monitoring, and ecosystem services assessment, which is testing an approach for national and global applications, and an NSF-funded project on extensive die-off of the red mangrove (*Rhizophora mangle*) on Abaco, Bahamas.

Professional preparation

Ph.D., Remote Sensing & GIS, Asian Institute of Technology, 1998
M.Sc., Natural Resources, Asian Institute of Technology, 1993
B.Sc., Forest Conservation, Tribhuvan University, 1987
B.Sc., Science, Tribhuvan University, 1987

Appointments

Chief, Sensing and Spatial Analysis Branch, Office of Research and Development, Environmental Protection Agency, Research Triangle Park, NC, May 2016 to present

Adjunct Faculty, Duke University, Durham, NC, September 2015 to present

Research Physical Scientist, U.S. Geological Survey Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD, July 2011 to April 2016

Senior Scientist, Contractor to the U.S. Geological Survey Earth Resources Observation and Science (EROS) Center, Sioux Falls, SD, October 2002 to June 2011

Senior Staff Associate, Columbia University, New York, October 2000 to September 2002

Program Specialist, United Nations Environment Programme (UNEP), Bangkok, Thailand, August 1993 to September 2000

Forest Officer, Department of Forests, Nepal, July 1988 to December 1991

Selected Publications

Ramdani, Fatwa, Sabaruddin Rahman, and Chandra Giri. "Principal polar spectral indices for mapping mangroves forest in South East Asia: study case Indonesia." *International Journal of Digital Earth* (2018): 1-15.

Chen, Bangqian, et al. "A mangrove forest map of China in 2015: Analysis of time series Landsat 7/8 and Sentinel-1A imagery in Google Earth Engine cloud computing platform." *ISPRS Journal of Photogrammetry and Remote Sensing* 131 (2017): 104-120.

Giri, Chandra. "Observation and monitoring of mangrove forests using remote sensing: opportunities and challenges." (2016): 783.Giri, Chandra, and Jordan Long. "Is the geographic range of mangrove forests in the conterminous United States really expanding?." *Sensors* 16.12 (2016): 2010.

Long, Jordan, et al. "Damage and recovery assessment of the Philippines' mangroves following Super Typhoon Haiyan." *Marine pollution bulletin* 109.2 (2016): 734-743.

Jones, T.G., Ratsimba, H.R., Carro, A., Ravaoarinorotsihoarana, L., Glass, L., Teoh, M., Benson, L., Cripps, G., **Giri, C.**, Zafindrasilivonona, B., Raherindray, R., Andriamahenina, Z. & Andriamahefazafy, M. (2016) The mangroves of Ambanja and Ambaro Bays, northwest Madagascar: historical dynamics, current status and deforestation mitigation strategy. In S. Diop, P. Scheren, & J. Ferdinand Machiwa (Eds.), *Estuaries: A Lifeline of Ecosystem Services in the Western Indian Ocean* (pp. 67-85). Springer International Publishing, Cham.

Giri, C., Long, J., Abbas, S., Murali, R.M., Qamer, F.M., Pengra, B. & Thau, D. (2015) Distribution and dynamics of mangrove forests of South Asia. *Journal of Environmental Management* 148:101-111.

Teoh, A.C., Glass, L., Cripps, G., **Giri, C.**, Gandhi, S., Andriamahenina, Z., Rakotomanana, R. & Roy, P.F. (2015) The dynamics, ecological variability and estimated carbon stocks of Madagascar's largest mangrove ecosystem. *Journal of Marine Science* (submitted).

Giri C. & Long, J. (2014) Mangrove reemergence in the northernmost range limit of eastern Florida. *Proceedings of the National Academy of Sciences*, 10.1073/PNAS.1400687111.

Myint, S.W., Franklin, J., Buenemann, M., Kim, W.K. & **Giri, C.** (2014) Examining change detection approaches for tropical mangrove monitoring. *Photogrammetric Engineering & Remote Sensing* 80(10): 983-993.

Long, J., Napton, D., **Giri, C.** & Graesser, J. (2014). A mapping and monitoring assessment of the Philippines' mangrove forests from 1990 to 2010. *Journal of Coastal Research* 294:260-271.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T. & Duke, N. (2011) **Status and distribution of mangrove forests of the world using earth observation satellite data**. *Global Ecology and Biogeography* 20(1):154-159.

Giri, C. (ed.) (2012) *Remote Sensing of Land Use and Land Cover*. Taylor and Francis/CRC Press, Florida, USA. 477 pp.