



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



**INNOVATIVE APPLICATION OF MACHINE LEARNING AND AI USING EARTH
OBSERVATION TO PROVIDE DATA AND ACTIONABLE INTELLIGENCE.**

CONOR G. SMYTH, ALEXIS SMITH
IMGeospatial (Intelligent Modelling Ltd.) U.K.
as@IMGeospatial.com
csmyth@IMGeospatial.com

**Paper prepared for presentation at the
“2017 WORLD BANK CONFERENCE ON LAND AND POVERTY”
The World Bank - Washington DC, March 20-24, 2017**



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



Copyright 2017 by author(s). All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

Abstract

Increasing proliferation and access to Earth Observation (EO) data presents both opportunities and challenges in terms with how we – as society deal with global scale societal, climatic and environmental issues. Fortunately, our ability to utilize and interpret the complexity and significant data volumes from remotely sensed data sources continues to develop apace, with the development and introduction of new, innovative and often, automated solutions. Many solutions are increasingly considered to be important integral elements of developing toolkits that provide understanding, evidence, insight and intelligence relating to the functioning of our world. It is therefore apt and timely that EO and innovative technical solutions are increasingly seen as essential for future policy development to bring about mitigating action or positive changes to our world in the face of diverse and varied global challenges such as global development and sustainability, land management, natural resources, climate change, risk mitigation and poverty alleviation. This paper aims to illustrate how the development and use of innovative techniques in the EO field utilizing machine learning and artificial intelligence can support many end application areas at various scales to build and support digital infrastructures, increase institutional or organizational capacity and to better inform policy making that promotes better land governance / natural resource management practices, sustainability, risk mitigation and/or resilience.

Key Words: Artificial Intelligence, Automatic Change Detection, Machine Learning, Resilience, Sustainability

INTRODUCTION

With the international importance of an ever-growing multi-billion global Space Earth Observation (EO) sector, the availability, provisioning and access to extensive geographical coverages of comprehensive and detailed imagery data, ranging from multi-spectral optical to radar data has never been more apparent. Many nations, including those in the developing world, have both active space research and satellite programs that annually augment the number and types of sensors launched into space orbit.

So whilst we are now facing a data deluge in EO data provisioning, future predictions relating to data creation, i.e. making intelligible sense of the data returned to earth, are significant to the extent that our capability to harness and interpret this data is increasingly challenged. Nevertheless, in recent years, there



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



has been a significant increase in the number of organizations – many SMEs, seeking to harness and utilize this EO data (as well as other remotely sensed data) in an attempt to tackle many global scale challenges through the development of innovative technological solutions.

Indeed, a significant shift relates very much to our growing technical capability as a society to monitor and assess our world at increasingly larger geographic scales – covering vast swaths of our continental land and ocean masses. More importantly, our ability to quantify ever more complex spatio-temporal changes through a global network of ‘sensors’, e.g. GEOSS, the Global Earth Observation System of Systems, is affording us enhanced capabilities in a range of fundamental areas. The future clearly has many prospects with the wider adoption of innovation technologies in this domain.

SIGNIFICANT GLOBAL CHALLENGES

What then does EO offer us in terms of tackling some of our most significant global challenges including contributing to poverty alleviation? Firstly, from a purely data or information perspective, the answer to that question undoubtedly is multi-stranded as EO offers us – society – a unique window on our world that contains an immense digital library of sensed data – often provisioned in near real-time, that can when harnessed and processed effectively, can provide us with real, tangible information – and much of it relating to elements (of the electromagnetic spectrum) that we as humans cannot sense nor see. Therein lies the immense value of remotely sensed data – and it is at scale, covering continental extents and more.

Of course, the aforementioned data ‘deluge’ is a undoubtedly a growing challenge, however, this proliferation has to be seen in the wider context of the pre-existing information environment as well as levels of development with respect to local, regional or national data infrastructures that support national administrations or governments. Often, in many functional areas of governance, these are less developed, limited, not fit for purpose or non-existent. This paper will refer to some of the challenges in this domain in due course.

Secondly, and moving momentarily away from data and information challenges, as a society, we all know that we are faced with significant and growing global challenges associated with demographic, climatic and environmental change as well as dealing with socio-economic cycles that in many parts of the world place sizeable proportions of their populations at even more significant risk or vulnerability, none more so in the case of natural disasters, e.g. droughts, storms, flooding, earthquakes and landslides, In the case of the



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



natural disasters, many of our most significant risks events are often magnified and at their most extreme in the developing world – where geographical location, climate and other factors inhibit mitigation. In those countries where poverty is more widespread, sizeable vulnerable populations are disproportionately affected, so the use of technology in areas where any reduction in vulnerability to physical hazards and risks is also going to impact beneficially on the human domain.

So does EO have a role to play in the context of these challenges? The answer is clearly a profound, ‘yes’. Undoubtedly, EO data and associated technologies have the potential to provide vital contributions to society’s collective approach to global challenges in a range of key areas, such as global development and sustainability, land management, natural resources, climate change, disaster risk mitigation and poverty alleviation. In the case of the latter, better knowledge and targeted action to counteract the impacts of physical or environment change clearly creates more stable environments whereby the most vulnerable populations are not exposed to further hardships through extreme events. Of course, economic and politic factors play a key role in creating the appropriate socio-economic environments to empower and grow their communities out of poverty into more progressive, stable socio-economic conditions.

In effect, increased societal resilience for a more sustainable world should have EO as its center both as a means to support and remedy information deficits but also and importantly to provide us with critical information or intelligence on global scale processes that have the potential to affect countries, regions and continents; and their populations. Without progress in this area, and with the pace of change globally, society is increasingly made more vulnerable if we cannot find technological and related solutions in tandem.

Whilst our global challenges are extremely diverse and vary in impact regionally, in recent years, opportunities for small innovation organizations to access, develop and deliver innovative technical solutions to meet these challenges has burgeoned.

The focus of this paper is to explore and briefly detail the novel innovative technology and approaches developed my IMGeospatial which, in the context of the data and information domain, have a significant range of application areas that through adoption potentially serve to impact upon more the development of more sustainable, evidence based approaches to the many challenges organizations, governments, civil society and nations face at various scales. In many ways, our methods and approaches have universal application.



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



A fundamental premise underpinning the development of machine learning and artificial intelligence solutions developed by IMGeospatial has been to bring about societal change through closing the ‘information’ gap in various sectoral areas – acknowledged as a significant challenge throughout many jurisdictions – for a variety of reasons. We seek to act as a catalyst in this area through the automated processing, interpretation and creation of insight and intelligence derived from remotely sensed sources. This is an area that is still in development globally, however, we consider our innovative approaches as world-class and leading the way to the creation of fully-automated data provisioning as well as serving to provide a monitoring change alert capability, i.e. dynamic and evolving information provision, in a machine to machine context. This capability serves to enhance governance and administration based on the utilization of ‘evidence’ or actionable intelligence for better decision-making, planning and targeted service delivery to those who need it most, i.e. to promote social inclusion.

In summary, and in the context of data and information challenges, our innovative solutions seek to:

- Illustrate how derived output (data intelligence) can offer real, tangible solutions to support critical societal challenges, including poverty reduction.
- Drive societal change through evidence-based service planning and policy development
- Reduce population exposure to urban and other hazards or risks including catastrophic natural disaster events through monitoring and information provision
- Promote the fully automated processing, interpretation and collection of data with no manual intervention
- Advance the closure of significant information gaps – at scale
- Increase data and information availability, its quality and accessibility primarily through direct integration into systems that feed planning, administration and/or services
- Reduce the costs associated with data husbandry, with recurrent costs of collection reduced
- Enhance data integrity, fitness for purpose and currency through auto-change updates thereby improving downstream systems, processes, planning, policy, services and delivery to citizens
- Promote data access and integration into other key or critical ICT systems



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



THE OPPORTUNITIES

Whilst the challenges are many and often of significant size or geographical scale, there are many opportunities for tackling these challenges through technology innovation. The paper aims to illustrate how the development and use of innovative techniques in the field of Earth Observation utilising machine learning and artificial intelligence can support many end application areas at various scales to build and support digital data infrastructures, whilst increasing institutional or organisational capacity to augment and better inform the policy making environment through access to information (and related change). Through such improvements, there is significant potential – effectively through data – to promote, amongst other things, better land governance and natural resource management practices, enhanced sustainability as well as improved risk mitigation practices, ultimately providing superior resilience.

At the general level, our technology supports innovation capacity in other domains; allows critical socio-economic and other challenges to be tackled through wider technology application to ultimately improve service planning, decision-making and policy support. It contributes significantly to sustainable development agendas and practices – as various scales through the application of differentiated, innovative, scalable AI solutions that can interface at platform and systems levels ultimately to provide greater societal and welfare benefits, for example, increased or improved access to services, increased social inclusion, improved governance, risk reduction to vulnerable population groups and wider society, warnings of emergency events or alerts and quicker, better targeted emergency response, to name but a few areas.

TECHNOLOGY SOLUTIONS

The use of machine learning and artificial intelligence in the EO domain is evolving at a rapid pace, however, not all solutions are as advanced or have the functionality to deliver scalable products or solutions.

The innovative work at IMGeospatial has led to the creation a number of key functional outputs (i.e. data insight, intelligence) as a result of our ability to automatically create representations of the topographic world in which we live – not only the physical aspects of features in the landscape but also the characteristics of the features (e.g. moisture level, texture, height etc.); importantly, such a capability can be extended to provide change detection monitoring and automated alerts and notifications – without human intervention, thereby providing administrations with data that they may not have had, as well as data on a periodic basis, thereby promoting information integrity, richness and currency. Without such data or



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



information intelligence, i.e. evidence, approaches to many facets of governance are substantially flawed or inhibited.

These developed capabilities have the potential for wider application in many sectoral areas in both generic ICT or geospatial systems as well as more specialist systems concerned with modelling (e.g. flooding, landslide risk etc.), inclusive of interfaces into wider digital ecosystems that integrate data feeds from multiple sources. In essence, our core offering is a ‘data as a service’ that is dynamic and actionable intelligence, depending on the end objectives or sectoral application area.

The key functional technology solution areas are:

- Automatic feature identification and extraction
- Classification of feature types including key ancillary details
- Identification of feature change and type
- Leak detection in underground pipeline networks
- Development of dynamic surface water flow pathways (pathways and ponds)

The use of automated topographic feature detection, classification (including their characteristics) and change over time, without manual intervention as well as the capability to provide systematic change updates (or alerts) and actionable intelligence will be showcased at the event thereby illustrating how such innovative functionality can be applied not only for land mapping and monitoring, but for a plethora of related end-uses, including planning.

Through the development of these innovative solutions for stakeholders and administrations, there are opportunities to establish or enhance existing spatial data infrastructures that enable increased participation and relationships in policy formulation, implementation and monitoring all within realistic timeframes. This is more so as the maintenance of the data records and underlying information, at a minimum, is of paramount importance to ensuring that, for example, land registers and maps reflect the situation on the ground day by day, thereby providing robust quantitative evidence such as contributions to economic growth and poverty reduction that are of direct interest to governmental administrations. Our technology serves to support improved information collection, governance and use as a vital key data source that provides authoritative and current information upon which plans, decisions and concrete actions, can be made more effectively to reach those recipients that need action most.



Responsible Land Governance: Towards an Evidence Based Approach

ANNUAL WORLD BANK CONFERENCE ON LAND AND POVERTY
WASHINGTON DC, MARCH 20-24, 2017



FUTURE ADOPTION

Like all challenges and opportunities, the ability to change to meet these challenges is predicated on many factors amongst them institutional, organizational, societal and financial. It is hoped, however, that with increasing technological developments and their wider systematic adoption, we should see incremental improvements in many areas of governance that are supported by evidence-bases that are fully integrated into the administrative ‘machinery’ of organizations and their many processes. With an ever-increasingly automated future based on technologies such as AI, our world may have gained essential tools from which we can better understand, plan and act with respect to many of the various challenges that society faces; such actions potentially will be pre-emptive and/or in real-time depending on application area reducing the requirement for reactive actions which are invariable responses that are too late and/or ineffective. Technology will not necessarily reduce our vulnerability, but it certainly will play an ongoing and pivotal role in increasing societal and institutional resilience amongst those nations that adopt new technology practices in totality or in conjunction with - and in support of - existing practices or modes of operation. Distilled information will always provide added-value and benefit to those who utilize it, therefore the development and management of data and information infrastructures will increasingly form a key framework upon which many other activities, processes and policies depend, especially those of administrative and government functions. It is hoped that such future adoption and new approaches will mark a new era in humanities interaction with our complex world for the benefits of citizens.