SA-YSSP 2014-15
Research Themes

Cluster 1: Risk, Policy, and Governance

SA-YSSP Research Theme 1

Extract of Africa: Towards the equitable and ecologically-sound governance of mining and drilling

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Background and motivation

The extractive industries are the economic backbone of many African nations, South Africa among them. The governance of these industries, however, is far from satisfactory. Indeed a recent report (Africa Progress Report 2013) observes that, in many countries, multinational companies and political leaders collude to swindle the citizens out of their just revenue from their natural resources. The prevailing alliance between corporations and state officials, the report continues, excludes both local communities and civil society. Extractive industries, in consequence, "leave the poor behind" and "harm the environment" (see also UNEP, 2013). This framework is unsustainable and has led to conflict in some countries. Whilst the project spans the sub-Saharan Africa, its main focus will be on South Africa – specifically on the fragile Karoo Biome and the proposed exploitation of its shale gas through fracking. Both environmental organisations and local communities, who oppose this project, fear that the Karoo's underground water may be irreversibly polluted by the fracking process.

Research theme

Mining, in most African countries, is an on-shore industry. In consequence, it inevitably competes for space with human and other ecological actors. Mining, therefore, increases the risk exposure of both sets of prior occupants. According to the theory of plural rationality, we can expect to hear four distinct "voices", each expressing its concerns over human vulnerability and environmental disturbance in a way that cannot be reconciled with the others. In the Niger Delta of Nigeria, for instance, the oil companies (individualist voice), the state (hierarchical voice), the activist groups (egalitarian voice) and the marginalized local communities (fatalist voice) hold wildly divergent views on environmental justice and governance. Since the afore-mentioned alliance between corporations and state officials results in the exclusion of the other two voices, conflict can easily erupt, and mutually constructive options can be overlooked. The project argues that, by finding ways in which these excluded voices can gain access, and then ensuring that all four are responsive to (rather than dismissive of) the others, governance will be improved. The research will: elicit the risk perceptions of different environ-

mental actors; examine how these "risk trajectories" interact; tease out ways of modifying these "whole system" interactions so as to evolve better forms of governance.

Relevant skills

Good background in environmental sociology, anthropology, economics, resource sustainability, social and environmental policy, and a good understanding of the discourses on land and resource contention in different African countries.

Recommended reading

Africa Progress Panel, 2013. Equity in Extractives: Stewarding Africa's natural resources for all. Retrieved from www.aricaprogresspanel.org

Thompson, M. 2000. Understanding Environmental Values: A Cultural Theory Approach. Retrieved from https://www.carnegiecouncil.org/publications/articles_papers_reports/710.html/_res/id=sa_File1/711_thompson.pdf

Thompson, M. 2008. Organizing and Disorganizing. Axminster: Triarchy Press.

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UNEP, 2013. Governance for Peace over Natural Resources: A review of transitions in environmental governance across Africa as a resource for peacebuilding and environmental management in Sudan. United Nations Environment Programme. http://unep.org/Sudan/

Verweij, M. 2011. Clumsy Solutions for a Wicked World. Basingstoke: Palgrave Macmillan.

Watts, M. 2006. Empire of oil: capitalist dispossession and the scramble for Africa. Monthly Review, Vol. 58, No. 4. Retrieved from http://www.monthlyreview.org/0906watts.htm#Volume.

SA-YSSP Research Theme 2

Social acceptance of land use requirements for renewable energy in South Africa: Critical considerations

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Background and motivation

With the advent of democracy in South Africa in 1994, the ANC-led government had identified land use and the redistribution of available land as a major challenge; this was further complicated by the country's need for infrastructure development and existing tensions between different groups of stakeholders within the country for land and energy.

The deployment of renewable energies in South Africa, mainly wind and solar, is driven by the goals of climate and energy security policy. South Africa is highly dependent on fossil fuels, with 75% of its energy demand being covered by coal, and to some extent by crude oil. Energy generation contributes to over 60% of greenhouse gas (GHG) emissions in the country (Banks and Schaffler, 2006; Blignaut et al., 2005). The level of GHG emissions in South Africa is the highest on the African continents, six times higher than the African average (Hoornweg et al., 2011), and is slightly below the average per capita GHG emissions of the G8 countries (Fulbright, 2014). At the same time South Africa's demand for energy will be tripled by 2050 as compared to 2010 (SAGEM, 2013). The South African government also recognizes an urgent need to deploy renewable energies. The political will is expressed in the ratification of international conventions and protocols on climate change as well as in the development of the Green Economy Accord. In 2013 the government published a framework called the South African Green Economy Modelling Report (SAGEM) to address critical issues relating to promoting a green economy, with the focus on prioritizing clean energy and energy efficiency (SAGEM, 2013).

Participation is central to good governance and various participation modalities require analysis. Traditionally the energy system planning approaches depended to a large degree on technical expertise, with the public voice existing on the periphery of the discourse. Research undertaken in North Africa and in the Middle East has indicated that social acceptance of large scale renewable energy projects cannot be taken as a given and the challenge is therefore to promote public participation. The harnessing of land and natural resources is central to South Africa's socio-economic growth. It has to also be noted that land is key to peace, stability and security, as many of the conflicts, especially in Africa, is centred on land – use management. Goal 8 of the Millennium Development Goals (MDG), which is to *Develop a Global Partnership for Development*, has a direct impact for land use and sustainable development as the poor need to be empowered through secure land rights which ensures their participation in social, economic and political decisions at the local, national and global level of policy and decision-making. The MDG's is also underpinned by a move to cleaner energy, which aims at reducing pollution and improving the living conditions of the poor and marginalized (Sustainable Development Report on Africa, ECA undated: 7).

Research theme

If the plans of the national government is to satisfy the growing energy demand and to decarbonize the electricity sector through the deployment of both, small scale energy generation projects but also large-scale energy generation and transmission projects such as concentrating solar power (CSP), large-scale photovoltaics (PV) or wind; requires large land areas for electricity generating, transmission and storage. Experience in other countries, shows that extensive land requirements for energy infrastructure can raise public protests against energy generation and transmission projects, in general, and renewable energy, in particular (Komendantova et al., 2013). However, scientific evidence about how disputes and conflicts about land use issues around large-scale renewable energy infrastructure in South Africa can be solved in frames of participatory governance is missing. Furthermore, evidence around public acceptance of large-scale projects and concerns around land-use issues is limited. The issue is also complicated by the fact that currently a significant proportion of South Africa's previously disadvantaged populations do not have access to land ownership and the question about equity and fairness in the distribution of large tracts of land for renewable energy generation also complicates the debate. Therefore, the major question in frames of this research is how disputes and conflicts around land-use issues can be solved in terms of democratic and equitable governance.

This research focuses on gaining an understanding of the dynamics of human and social behavior by gauging the interrelations between renewable energy, land use management and the environment. The units of analysis revolve around social acceptance of devoting large land areas to renewable electricity generation. In addition, the proposed research aims to provide recommendations for social structures, particularly institutional, that creates and defines land use management. In addition, it assists society at large, communities, government and private organizational capabilities to govern and manage insightful and swift land use management in the renewable energy sector. Consequently, the research investigates land use management challenges, addresses the areas of decision-making to understand individuals' and society's response to selecting options among choices available for land use management.

These conflicting challenges therefore lead to the following critical questions on the social acceptance of land use management and renewable energy:

- What is the governance issues surrounding social acceptance of land use management and renewable energy generation?
- What are the social implications of transforming land for renewable energy generation?
- Which forms of public involvement are feasible given South Africa's land redistribution/ restitution frameworks?
- What are the governance options to resolve competing interests for scarce resources such as primary land and renewable energy generation?
- What is the international best practice for land use management and renewable energy generation?

From a theoretical point of view, the *game theory* of land use management indicates that involving communities in the social acceptance of decision-making processes, for example land use manage-

ment, may improve policy outcomes (Samsura et al., 2009). A case study method will be used to understand social acceptance around infrastructure projects.

Relevant skills

Suitable candidates should be registered for a PhD programme in one of the following disciplines: Public Management and Governance, Political Science, Economic Science, Development Studies or any other related discipline. Candidates should be proficient in both quantitative and qualitative research methodologies. A good command of the English language (written and spoken) would be advantageous. Finally, a strong interest in stakeholder analysis, participatory governance, social acceptance challenges and renewable energy would be advantageous.

Recommended reading

Key readings are indicated with an *.

*Baker, L. 2011. Governing electricity in South Africa: wind, coal and power struggles. The Governance of Clean Development Working Paper Series. Available at: http:/www.uea.ac.uk/dev/gcd/Baker=2011

*Banks, D. & Schaffler, J. 2006. The potential contribution of renewable energy in South Africa: Draft Report. Sustainable Energy and Climate Change Project: Johannesburg.

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Department of Environmental Affairs (Republic of South Africa). 2013. Green Economy modelling Report of South Africa. Pretoria. SAGEM.

Economic Commission for Africa. Undated. Sustainable Development Report on Africa. Managing Land-Based Resources for Sustainable Development. United Nations.

*Edkins, M., Marquard, A. & Winkler, H. 2010. South Africa's renewable energy roadmaps. Energy Research Centre Report, June 2010: University of Cape Town.

*Hernandez, R. R., Hoffacker, M. K. & Field, C. B. 2013. Land use efficiency of Big Solar. Available at: http://adsabs.harvard.edu/2013

Komendantova, N. 2013. Evidence of five guiding principles in Infrastructure projects. Deliverable 2.1, Best practices background report, BESTGRID Project, Brussels.

Nel, V. 2011. Land-use management system as a tool towards achieving low-carbon cities in South Africa. [online]. Available at: https://www.google.co.za/verna+nel

*Norton Rose Fulbright. Undated. Scaling-up renewable energy in Africa: South Africa. Available at: http://www.nortonrosefulbright.com/knowledge/publications

Ong, S., Campbell, C., Denholm, P., Margolis, R. & Heath, G. 2013. Land-use requirements for Solar Power Plants in the United States. National Renewable Energy Laboratory.

Samsara, D. A., Krabben, E. & Deemen, A. M. A. 2009. A game theory approach to the analysis of land and property development processes. Land Use Policy. (27): 564-578.

Sunday Times. Solar plants a ray of hope amid SA's power gloom. 27 April 2014.

SA-YSSP Research Theme 3

Sustainable cities – Cities as forces for good in the environment

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Background and motivation

One of the dominant trends of the current century is urbanization. Cities are just as dominant in the global economy. Whatever can be done to make cities ever more environmentally sustainable will be key to reconciling human development and the needs of national economies with humankind's capacity to live within Earth's finite resources and climate. This challenge was first expressed in an essay written by three IIASA Institute Scholars in 2006/7 (Crutzen, Beck and Thomson, 2007). The research on Cities as Forces for Good (CFG) in the Environment was essentially started in 2006 under the pioneering effort Professor Beck and Dr Thompson, and currently it has become an international research network (www.cfgnet.org). Although, the origins of CFG lie in the water sector (Beck *et al*, 2010, 2011), today, however, this programme of research addresses interactions among the water, energy, food, waste-handling, and forestry sectors (Beck *et al*, 2013). Under this umbrella the research agenda of the project Sustainable cities- Cities as Forces for Good (CFG) in the Environment focuses on the application of systems analysis to develop methodologies as well as policy interventions, which will help in attaining sustainability in cities within the constraints of resource availability, environment and climate change.

Research theme

The over-arching challenge of the project Sustainable Cities - Cities as Forces for Good (CFG) in the Environment is that how can the infrastructure and economy of cities be re-engineered such that they may become forces for good in their environments. It seeks for synergies among any of the sectors such as water, food, energy, transport, climate and so on relevant to make the cities less unsustainable. However, the purview of the proposed research on Sustainable Cities/CFG is also likely to expand to include, for instance, better accounts of the urban Information Technology (IT) sector and the urban Public Health sector. Besides, it will seek to comprehend how uncertainty and plural rationalities might be accommodated within (and therefore extend) the framework of Systems Dynamics, which is believed to be otherwise well suited to studying the challenges of making cities in Africa (and Asia) less unsustainable.

Thus, it is envisaged that the research projects will be within the broad theme of Sustainable Cities - Cities as Forces for Good (CFG) in the Environment and will deal with sustainability issues of urban areas, such as, but not limited to, Water, Food, Energy, Transport, Health, Information Technology, and Governance by using the methods of Applied System Analysis (which include, for example, Systems Dynamics, Substance Flow Analysis, Integrated Assessment Modeling, and theories of plural

rationalities (Cultural Theory) for understanding urban governance) and provide policy guidance on the development and implementation in order to achieve the goals of CFG.

Relevant skills

Students should already be working on, or have an interest in, cities, their infrastructure, and their governance. Ideally, they should be in a situation to begin their research during the SA-YSSP with background data assembled for a specific city case study. It would be highly desirable, but not absolutely essential, for students also to be familiar with the use of computer modeling, as in systems modeling, agent-based modeling, integrated assessment modeling, material flow analysis, Monte Carlo simulation, uncertainty and sensitivity analyses, optimization, or mathematical decision analysis. It will be highly beneficial if the young scientists have become acquainted with relevant statistical analysis, through the use of statistical software packages, such as SPSS or SAS.

Recommended reading

Achillas Ch., Vlachokostas Ch., Moussiopoulos N., Banias G. (2011). Prioritize strategies to confront environmental deterioration in urban areas: Multicriteria assessment of public opinion and experts' views, Cities 28 414–423.

Beck MB, Jiang F, Shi F et al. (2010) Re-engineering cities as forces for good in the environment. Proceedings of the Institution of Civil Engineers – Engineering Sustainability 163(1): 31–46.

Beck MB, Thompson M, Ney S, Gyawali D and Jeffrey P (2011) On governance for re-engineering city infrastructure. Proceedings of the Institution of Civil Engineers – Engineering Sustainability 164(2): 129–142.

Beck M (2013). Why Question the Existing Paradigm Of Wastewater Management? Chapter 34 in: Larsen TA, K.M Udert and J Liernert eds. Source Separation and Decentralisation for Wastewater Management, IWA Publishing.

Beck M.B, R. V Walker and M Thompson (2013). Smarter urban metabolism: Earth systems re-engineering. Proceedings of the Institution of Civil Engineers, Engineering Sustainability 166 October 2013 Issue ES5: 229–241.

Crutzen, P Beck MB, Thompson M, (2007). Grand challenges for engineering, Turning cities into forces for good in the environment, Options, p 8, Winter 2007, www.iiasa.ac.at.

Farmer, P., Frojmovic, M., Hague, C., Harridge, C., Narang, S., and Shishido, D. (2006) Reinventing planning: a new governance paradigm for managing human settlements, In Position paper for the World Planners Congress, Vancouver.

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Huang, S.-L., Yen, C.-T., Budd, W., & Chen, L.-L. (2009). A Sensitivity Model (SM) approach to analyze urban development in Taiwan based on sustainability indicators. Environmental Impact Assessment Review, 29(2), 116–125.

Luque-Martínez, T., & Muñoz-Leiva, F. (2005). City benchmarking: A methodological proposal referring specifically to Granada. Cities, 22(6), 411–423.

Moussiopoulos, N., Achillas, C., Vlachokostas, C., Spyridi, D., and Nikolaou, K. (2010) Environmental, social and economic information management for the evaluation of sustainability in urban areas: A system of indicators for Thessaloniki, Greece, Cities, 27, pp. 377- 384.

Nomdo, C. and Coetzee, E. (2002) Urban vulnerability: Perspectives from Southern Africa, Stylus: Sterling VA.

Olewiler, N. (2006). Environmental sustainability for urban areas: The role of natural capital indicators. Cities, 23(3), 184–195.

Saavedra, C. and Budd, W. W. (2009) Climate change and environmental planning: Working to build community resilience and adaptive capacity in Washington State, USA, Habitat International, 33, pp. 246–252.

UN-Habitat. (2009) Sustainable urbanisation: Revisiting the role of urban planning, Global report on human settlements, Nairobi: UN-Habitat.

Cluster 2: Energy and Climate Systems

SA-YSSP Research Theme 4

GAINS model for integrated local and regional air quality and climate modelling in southern Africa

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Background and motivation

Inhalation of fine particulate matter generated by anthropogenic activities (primarily from cooking, electricity generation, vehicles and industry) is recognised as a major global contributor to increased morbidity and premature mortality. There is a need to quantify the sources, transport routes, exposure and health outcomes of these atmospheric emissions on national and regional scales to assist in policy formulations. As energy production, air pollution and greenhouse gas emissions are inextricably linked, any model needs to incorporate all three of these aspects in an integrated platform. The *Greenhouse Gas and Air Pollution Interactions and Synergies* (GAINS Model), developed by IIASA and partners in the European Consortium for Modelling of Air Pollution and Climate Strategies was developed for this purpose. To date, the model has been applied to the European Union, East Asia and South Asia – this project proposal is part of the first activities to apply the model to the South(ern) African region.

Research theme

A set of related projects is envisaged:

1. A conceptual systems analysis of the GHG and atmospheric emissions in southern Africa, (natural and anthropogenic), and an analysis of the extent to which the GAINS model could incorporate these into the modelling framework.
2. A policy analysis of the potential role that externality costs, as derived from GAINS modelling scenarios, could inform energy infrastructure, environmental protection and GHG mitigation decisions in South and southern Africa.
3. A survey of available national and regional data sets required to populate a southern African GAINS implementation, with identification of data owners, and critical gaps.
4. A preliminary framework implementation of the GAINS model, using current data available in the public domain.
5. An analysis of the extent to which the GAINS model, based on a top-down regional approach, would need to be supplemented with localized intense ground level exposures to achieve a comprehensive health outcome assessment in the South African.

Each of these projects would require the participants to work with the publically (web-based) implementations of GAINS to derive an understanding of the *systems approaches* underlying this model, and to contribute understanding of further work to be carried out generate or assemble data sets suitable for a full-scale implementation.

A shared task of the group would be to assemble and critically analyze South Africa's current energy infrastructure policies and implementations; air quality management and climate change policies; and health vulnerabilities as far as air pollution is concerned. Currently, there is little interchange between the three major government departments dealing with these issues, hence the need to work towards a *systems approach* that could form a platform for further integrated policy development.

Relevant skills

The applying doctoral students would have a broad interest within the fields of atmospheric environment, energy, global change or public health. They could either have a broad systems approach, or have specialized skills, particularly in handling and interpreting large data sets and complex modelling environment. Expertise in programming platforms such as MATLAB would be valuable. Students with expertise in atmospheric chemistry, GHG and atmospheric emissions inventories, environmental economics, policy or law could make valuable contributions within the framework of this transdisciplinary project.

Recommended reading

Rao S, Pachauri S, Dentener F, Kinney P, Klimont Z, Riahi K, Schoepp W (2013). Better air for better health: Forging synergies in policies for energy access, climate change and air pollution. Global Environmental Change, 23(5):1122-1130.

Amann M, Klimont Z, Wagner F (2013). Regional and global emissions of air pollutants: Recent trends and future scenarios. Annual Review of Environment and Resources, 38:31-55 (October 2013)

Frost GJ, Middleton P, Tarrason L, Granier C, Guenther A, Cardenas B, Denier van der Gon H, Janssens-Maenhout G, Kaiser JW, Keating T, Klimont Z, Lamarque J-F, Liousse C, Ohara T, Schultz MG, Skiba U, van Aardenne J (2013). New directions: GEIA's 2020 vision for better air emissions information. Atmospheric Environment, 81:710-712 (December 2013).

Liousse C, Assamoi E, Criqui P, Granier C & Rosset R (2014). Explosive growth in African combustion emissions from 2005 to 2030. Environ. Res. Lett. 9: 035003 (10 pp) doi:10.1088/1748-9326/9/3/035003. (Open access).

Zusman E, Miyatsuka A, Evarts D, Kim Oanh NT, Klimont Z, Amann M, Suzuki K, Mohammad A (2013). Co-benefits: Taking a multidisciplinary approach. Carbon Management, 4(2):135-137.

Liu F, Klimont Z, Zhang Q, Cofala J, Zhao L, Huo H, Nguyen B, Schoepp W, Sander R, Zheng B, Hong C, He K, Amann M, Heyes C (2013). Integrating mitigation of air pollutants and greenhouse gases in Chinese cities: Development of GAINS-City model for Beijing. Journal of Cleaner Production, 58:25-33 (1 November 2013).

The website of the GAINS model is: http://gains.iiasa.ac.at/models/.
Register and explore the publically open European and China implementations.

SA-YSSP Research Theme 5

Mitigation of air pollution and greenhouse gases

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Background and motivation

The proposed project(s) are in the field of energy sustainability and mitigation of greenhouse gas emissions, environmental aspects and pollutants in the sector. This contributes to the field of environmental sustainability and renewable energy. The aim is to identify more sustainable energy systems and usage methods in South Africa. Energy is the life line of economic development and there is need to use it in a way that is sustainable, efficient and environmentally friendly if the quality of life and well-being of the planet earth, plants and animals is to be assured. Sprawling and fast growing urban areas, renewable energy resources and technologies and all energy-consuming human endeavours in South Africa are candidates for improved environmental performance. This can be during any phase of the life cycle of the activities and systems or can also be tackled from a life cycle perspective. The work done in these areas can contribute discourse and decision-making in energy and sustainability.

Research theme

The focus of the research shall be the setting up of an energy model for South Africa, taking into account the point mentioned in in the above chapter 'Background and Motivations'. The general area of research is in energy and environmental sustainability. The aim is to identify ways to use energy in a way that supports development whilst controlling or reducing pollution and greenhouse gases to acceptable levels. The typical possible projects in this area are as follows:

1. Trends, Drivers and Trajectories for urban energy-related Greenhouse Gas emissions: Urban areas are major consumers of energy and contribute to a lot of greenhouse gas emissions. One or more major cities may be studied with a view of establishing historical annual energy-related greenhouse gas emissions for one year. Models can then be developed for forecasting greenhouse gas emissions in the next few decades and ways to mitigate them.
2. Renewable Energy Technologies and their potential for greenhouse gas reduction: One type of renewable energy can be focused on: wind or biodiesel or ethanol from sugar or cellulosic ethanol; or bio-power or solar energy etc. The impact of using such an alternative energy on greenhouse gas emissions can be assessed using any chosen modelling tools.
3. Energy Efficiency: The management of energy and the rational use of energy can be investigated in a specific sector. The energy reductions need to be quantified as well as the financial penalties or benefits related. Models can be developed and policy interventions proposed.
4. Cogeneration potential with a focus on one or more industrial sectors. The production of power and steam is peculiar to the sugar, chemical and processing industries. High energy efficiency can be attained through the development and design of feasible cogeneration sys-

tems. The cogeneration potential in a given sector can be modelled and policy interventions provided.

5. Improving the modelling of greenhouse gas emissions in the agricultural industry: There have been several attempts to models greenhouse gas emissions and this work can involve model development and better data collection methods so that the estimations are as close as possible to reality.
6. Greenhouse gas emissions in the energy industry: These can be modelled from historical, current and future consequences perspective.
7. Introducing life cycle assessment methods to pollution and greenhouse gas mitigation in a specific sector. Greenhouse gas emissions are normally measured using annual historical data. A life cycle assessment perspective considered total emissions from cradle to grave including many years of useful life and not just one year.
8. Setting up of an energy model for South Africa or any other country of interest. The sustainable is-sue is the main focus on the research. To analyse sustainable development in energy supply, the set-up of an integrated energy model is a cornerstone. The focus of the work can be on the changes in land use or on future land needs for agriculture, farming, foresting, and city development necessary for designing a sustainable future for the country. This work could be based on IIASA's biomass model GLOBIOM. Another focus can be on future energy technologies development in South Africa. Be it solar technologies, wind farms, or conventional energy generating systems as part of the future energy supply system in South Arica. The important task is to analyse the social impacts as well as the environmental impacts of future energy supply options over their complete life cycle. Also a model could focus on the development of energy demand. The IIASA model GAINS could be an important basis for this focus. This model also looks at emissions and emission standards hence very important for sustainable development.

A model can be developed that integrates different themes into an overall national or regional energy model. This can take into consideration the differences between urban and rural development. The IIASA model MESSAGE could be a basis for this development. One additional task could be the integration of this model into the global energy model.

Relevant skills

The students must be able to collect relevant data applicable to energy sustainability. The student must be able to develop suitable and comprehensive models in the chosen topic area. Agricultural and cellulosic ethanol topics demand some knowledge of chemistry, process or chemical systems/ science or engineering. Energy topics require basic knowledge of thermal and fluid sciences and electrical systems. Life cycle assessment requires that students have basic knowledge of environmental life cycle assessment methodologies. All require good knowledge of research methodology applied to energy and greenhouse gas mitigation. For modelling topics, successful candidates shall have keen interest in applied system analysis and proven skills in at least one of the following areas: operations research (in particular methods and tools for mathematical modelling, integrated model analysis, data analysis), energy systems, energy efficiency, and land-use matters.

Recommended reading

GEA, 2012: Global Energy Assessment - Toward a Sustainable Future, Cambridge University Press, Cambridge, UK and New York, NY, USA and the International Institute for Applied Systems Analysis, Laxenburg, Austria.

Achieving a Sustainable Global Energy System: Identifying Possibilities Using Long-Term Energy Scenarios, L. Schrattenholzer, A. Miketa, K. Riahi, R.A. Roehrl (eds) Edward Elgar, Cheltenham, UK [2004].

Blottnitz, v. H. and Curran, M.A. (2007). A review of assessments conducted on bio ethanol systems from an energy balance, CO2, and environmental life-cycle perspective. Journal of Cleaner Production 15: 607–619.

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Cluster 3: Ecosystems and Water

SA-YSSP Research Theme 6

Climate-change-food nexus: Merging top-down and bottom-up knowledge to address sustainability

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Background and motivation

Climate change will significantly impact agriculture by increasing water demand, limiting crop productivity and reducing food security in sub-Saharan Africa (SSA). SSA is a region exposed to multiple stresses and has been identified as very vulnerable to climate change impacts. In this region, the impacts across sectors may interact in complex ways with one another producing potentially cascading effects that are largely unpredictable. This research theme takes a socio-ecological perspective. It seeks to learn from insights on how ecological and socio-economic sub-systems interact—and when and why they collapse—and to understand whether our knowledge on sustainability proves relevant across scales, from local to regional/sub-global and vice versa. The climate change-food nexus—with downscaled climate model output, limited but of prognostic nature, on the one hand and precious indigenous/local expertise, possibly gained from system failures, on the other hand—serves as our test ground for collecting and scrutinizing these insights. The overall objective is to better understand how to overcome the dilemma posed by local actions and larger-scale (planetary) boundaries in sustaining ecosystem services.

Research theme

Food security is one of the most daunting challenges of SSA. The economies of SSA are highly dependent on agriculture. Agriculture in SSA is rain-fed in most cases and very sensitive to weather and climate variables, hence agriculture is very vulnerable to climate change in countries with low potential to adaptation. This research theme will focus on both global climate change models (GCMs) and indigenous knowledge systems as a means to plan for adaptation. Seasonal climate focusing offers good potential to add decision making for climate risk management at district and local levels. Adaptation planning is occurring and will continue to occur in an environment of uncertainty concerning trajectories of future greenhouse gas emissions, and the direction of climate change and the influence of feedbacks on climate systems and those from land use, land cover changes. The planning will significantly affect the magnitude of future impacts and the ability of society to adapt. Recent advances in climate have begun to address some of the uncertainty. Good agreement exists among various climate change models. However, GCMs simulate the whole earth with a relatively course spatial resolution. The spatial scale can include a few hundred kilometers and larger. Regional climate models (RCMs) downscaled from GCMs have a higher resolution of a few kilometers only. Downscal-

ing GCMs can provide a powerful alternative for adaptation planning. RCMs as well as local (potentially complex) models generated bottom-up are useful for identifying general sensitivities to climate change and enhancing adaptation to climate change. On the other hand, information on local adaptation practices and indigenous knowledge concerning the intricate interdependencies of sub-systems should be used when linked with the outputs of RCMs and GCMs in order to help farmers and local populations adapt to climate change.

Relevant skills

A good background in agronomy and soils, climate modeling sciences, as well as farming and resource-management systems within given cultural settings is needed to contribute meaningfully to this research area. Systems-analysis type of modeling will be required to better understand and quantify interdependencies between sub-systems and potential feedbacks.

Recommended reading

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SA-YSSP Research Theme 7

Dynamical systems in ecology: Models, analysis, and simulations

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Background and motivation

Networks and nonlocal interactions are abundant in ecological systems. Modeling the time-dependent phenomena in such a framework usually is done by compartmental ordinary differential models. The drawback is that differential equations only can describe local interactions without taking account the processes due to long-range interactions such as occurring along the network edges. However, the evolution of most real systems is driven by interactions which extend in space, in time, and also across various levels of organizations of matter. The main objective of research is analyzing partial differential equations on networks coupled through various, possibly nonlocal interactions at the nodes. Such models may stretch across various levels of organization of matter, from the micro to the macro scale and these scales are present in them, forming so-called multiple scale models. The complexity of such models makes a robust analysis of them difficult. Hence it is important to be able aggregate the variables of a multiple scales (micro) models to build simpler (macro) models, which, nevertheless, provide similar dynamics. At the same time, since there is an interdependence of various levels of description, there should be a `shadow' of the levels that were discarded at the aggregated level.

The aim of the project is to analyze models with special attention to their asymptotic behavior, both in time and with respect to the scaling parameters. A successful application of the asymptotic analysis to such systems will provide a robust approximation of their dynamics without compromising the accuracy of the description. Such an analysis requires a deep understanding of both the original (micro) and the target (macro) systems which can be done at an abstract level by employing and developing new mathematical tools creating thus an extensive network of new links between pure and applied mathematics and life sciences.

Another angle of research is looking at such problems from the point of optimization theory e.g. to find optimal ways of exploitation of resources.

Research theme

The project described below outlines a general field of research and is open ended. It contains several smaller but nevertheless challenging projects and the potential students are free to choose some particular topics out of this proposal.

The research will be focused on identification, analysis and simulation of nonlocal models of:

- fragmentation and coagulation describing processes such as animal grouping and splitting, evolution of phytoplankton aggregates, blood agglutination,

- age structured epidemiological models with nonlocality due to e.g. intercohort infections as well as birth processes giving rise to nonlocal boundary conditions,
- invasions of species,
- transport and diffusion problems on networks with node interactions given by processes in the above list,
- optimal exploitation of renewable resources in stationary or periodic mode,

as well as considering multiscale problems coupling the some of the above models and their asymptotic analysis.

Our main objective is theoretical understanding of the properties of such models. In particular, we are interested in

- well-posedness of the problems,
- finding optimal solutions with respect to specific cost functions,
- existence of steady state solutions and analysis, their stability and the long term behaviour of solutions,
- aggregation of variables and rigorous construction of macro-models.

Relevant skills

The projects are aimed at students interested in mathematical biology, mathematical ecology and mathematical modeling. The skills needed are:

- Good understanding of ordinary and partial differential equation models in life sciences
- Working knowledge of dynamical systems, ordinary and partial differential equations
- At least basic functional analytic skills
- Some numerical skills to illustrate theoretical findings.

Recommended reading

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A. Bobrowski, Convergence of one-parameter operator semigroups. In models of mathematical biology and elsewhere, Cambridge University Press, to appear.

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SA-YSSP Research Theme 8

Modelling mechanisms influencing above- and below-ground diversity and productivity in plant communities

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Background and motivation

Soil microbes inhabiting the rhizosphere play a crucial role in determining plant fitness, productivity, and health. Their role has been highlighted in studies of mutualistic and antagonistic interactions, both in natural ecosystems affecting the diversity and stability of communities, and also in agro-ecosystems directly affecting crop yields. Besides the biological aspects often studied, also various biochemical mechanisms influence rhizosphere diversity, which in turn stabilizes interactions that positively or negatively affect plant species and community diversity, stability, or resilience. Allelopathy, the inhibition of others by chemicals, is one potential mechanism responsible for determining agricultural productivity and plant community structure. Modelling allelopathy in a multi-species setting in spatially explicit models will contribute to a broader understanding of the diversity, stability, and productivity of above- and below-ground communities.

Research theme

This project will focus on modelling plant community dynamics in a multi-species setting. At the same time, it will interface this objective with the consideration of multi-player cooperation models, thus creating a link between modelling plant community dynamics and cooperation research. Cooperation research focuses on the evolution and stability of different strategy types involved in potentially cooperative interactions, for example investing more or less into producing chemical products that may inhibit other members of a community. Interaction between these different strategies will then affect the diversity, stability, or productivity of communities. Among the numerous theoretical approaches, agent-based modelling is an appropriate tool for the theoretical study of plant community dynamics with such complex interactions. Agent-based models can also be used for modelling spatially explicit populations, in which individuals have limited movement and localised interactions, which fits the study of plant communities. The scope of this project is to develop and/or analyze such a model for understanding plant community dynamics in a multi-species setting considering interactions through chemical products. In addition to these theoretical aspects, the project will also consider applied aspects of plant community dynamics, by comparing model results with data, and by making predictions about the effect of human actions, such as fertilization strategies or crop-mixing strategies, on plant community diversity, stability, and productivity.

Relevant skills

Ecological modelling, microbial ecology, skills in mathematics, spatially explicit modelling, agent-based modelling, Matlab/ C/ Delphi (or similar programming platform); interest in interactions between species and their abiotic environment.

Recommended reading

Blanco, J.A. (2007) The representation of allelopathy in ecosystem-level forest models. Ecological Modelling 209: 65–77. Available online at http://www.sciencedirect.com/science/article/pii/S0304380007003225

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SA-YSSP Research Theme 9

Resilience measures in ecosystems and socio-economic networks

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Background and motivation

Ecosystem resilience is a popular research agenda due to the degradation of many ecosystems brought about by human interferences, such as over-use, exploitation or pollution, as well as due to their intriguing complexity which is as yet poorly understood. Although funders, politicians, managers and researchers are interested in keeping ecosystems as life support systems more or less intact, there is as yet no consensus as to what constitutes a resilient ecosystem. This is mostly because we have little understanding of thresholds in empirical system, while we are beginning to understand some of the thresholds in theoretical systems. The challenge of establishing a "range of resilience" for each ecosystem is supported by little knowledge of variability of ecosystem growth or functioning, and adequate indices to describe such variability.

Research theme

Resilient ecosystems in general maintain an adequate functioning, which is determined by interactions between species, and between species and their abiotic environment. In order to describe such interactions and resulting macroscopic patterns, network analysis has been used as one of the tools. Although several ecosystem properties pertaining to resilience have been put forward by the research community, it is not yet clear which of these, or which combination thereof, describe ecosystem resilience adequately. Most of these describe patterns of links within a system such as network connectivity, flow diversity, estimate constraints on energy moving through the systems, node centrality and many others. However, for none of these have theoretical ranges or thresholds been explored, and their interrelated response to disturbances in empirical systems is poorly understood.

Therefore, there are both theoretical and applied aspects to this project to explore existing indicators for resilience, and there is furthermore plenty of scope to explore new resilience indicators, using network analysis, in a setting of empirical ecological and socio- economic networks. The comparison of the different types of networks furthermore opens opportunities to examine discrepancies and similarities between natural self-sustaining (ecosystems) and anthropogenically fashioned (socio-economic) networks. The outcome of this project is envisaged to be a spectrum of several network analysis measures that adequately describe ecosystem resilience.

The outcome of this project is envisaged to be a spectrum of several network analysis measures that adequately describe system resilience.

Relevant skills

Ecological modeling, network analysis, ecology, MATLAB (or similar programming platform), a keen interest in network analysis and network related research questions.

Recommended reading

Key readings are indicated with an *.

*Christensen V & Walters C.J (2004). Ecopath with Ecosim: Methods, capabilities and limitations. Ecological Modelling 172: 109–139. DOI: 10.1016/j.ecolmodel.2003.09.003

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Tilly L.J (1968). The Structure and Dynamics of Cone Spring. Ecological Monographs, 38, 169–197. DOI: 10.2307/1942291

Williams R.J. & Martinez N.D (2000). Simple rules yield complex food webs. Nature 404, 180–183, 2000. DOI: 10.1038/35004572

SA-YSSP Research Theme 10

Stability and complexity of adaptive ecological networks

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Background and motivation

Forty years ago, Robert May published his iconic book, 'Stability and Complexity in Model Ecosystems'. In this book, May challenged a popular belief of ecologists, that species-rich ecosystems are more stable than species-poor ones. Using a mathematical model of differential equations, May derived the opposite conclusion: complexity leads to instability. May's principle of 'simple means stable' has guided the design of durable and robust complex systems by reducing the number of their compartments. Learning from ecological systems, here we envisage a paradigm shift departing from May's principle by incorporating adaptive compartments. For this purpose, we aim to expand the methodology of adaptive dynamics theory, a mathematical toolbox recently developed for examining phenotypic evolution in realistic ecological settings. The new perspective we propose emphasizes that complex adaptive systems assemble their members and often cause these to diverge into functional clusters.

Research theme

An important assumption in the early theories is that species in a community are not allowed to have ecological novelty or evolutionary novelty. Ecological novelty refers to the ability of species to increase their fitness by deciding, adaptively and at ecological time scales, how strongly they interact with extant other species. Evolutionary novelty refers to the ability of species to increase their fitness by adapting their heritable traits via natural selection. Here we propose to build a mathematical model that incorporates both ecological and evolutionary novelties in a large ecosystem with a realistic number of species. Using adaptive dynamics theory, we plan to first construct an ecosystem following May's approach; that is, a Lotka-Volterra model with each species described by a differential equation. The mutualistic and antagonistic relationships among these species will be described by Holling-type-II functional responses. We will allow species to choose their interaction partners and adapt their interactions through the mutation and selection of the underlying traits. In this way, we will design the first model that allows changes both in the interaction matrix and in the benefit matrix. The relationship between diversity and complexity will be assessed by this innovative adaptive model.

In addition to the research theme summarized above, we are open to supervising projects in all other areas of theoretical ecology and the analysis of complex adaptive systems. This includes studies of the dynamics and evolution of cooperation; adaptive response of metapopulations, ecosystems, and biodiversity patterns to environmental changes; evolution of virulence and resistance in diseases; adaptive management of landscapes, vegetation structures, and fisheries; as well as analyses of systemic risks. Projects in all of these areas may have an analytical component, and will typically involve a simulation-based numerical approach.

Relevant skills

Applicants should have mastered at least one programming language (such as Matlab, Mathematica, R, C, C++, Basic, Delphi, or Pascal) and should ideally be familiar with the stability analysis of differential equations, methods of adaptive dynamics theory, and standard models in population ecology, community ecology, and evolutionary ecology.

Recommended reading

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SA-YSSP Research Theme 11

Water futures and solutions: Climate change and water security in Africa

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Background and motivation

The quest for water security has been a struggle throughout human history. Only in recent years has freshwater started to become a globally scarce good and have water-related risks become so interconnected that the scale of this quest has needed to move beyond the local, to the national and regional scales and to the planet itself. It has been reported that lack of or unreliable water supply, sanitation and irrigation services, unmitigated floods and droughts, and degraded water environments severely impact half of the world's population. Water resources are central to development and poverty alleviation. Yet decision makers face many challenges to ensuring their sustainable and equitable use. The impacts of rapidly changing economies, populations and climate change on fresh water resources are unknown, especially for regions in Africa. Although average precipitation across Africa is similar to Europe, African water resources are more highly varied over time and space, meaning that developing the resources to the low level of risk enjoyed by European citizens would require considerably greater resources which are not available. Furthermore, much less scientific knowledge is available in Africa than in OECD countries that have been carefully monitored and evaluated for decades. The impact of climate change on water resources in Africa, for example, is very uncertain.

Building on its long history of applying world-class science to the resolution of grand challenges, IIASA launched a new flagship programme "Water Futures and Solutions" (WFaS) in 2012, bringing to bear its unique skills, datasets, policy links and reputation. WFaS brings state-of-the-art science and decision makers together to develop realistic future scenarios that decision makers can use to identify and prioritize robust options to meet these challenges. Although the main aim of the project is to provide widely accessible global tools and data sets that are consolidated, integrated and applicable across different scales, it is hoped that the initiative, with its associated case studies, could provide datasets and scenario information at the country-level, which could be regarded as the most appropriate level for policy making. The project needs to mobilize individual countries or **regions** with shared needs and priorities to address them jointly. "Important social science dimensions were lacking in previous water scenarios - this time, people's behaviour needs to be taken into account, with a focus on specific questions and relevant scales" (Bill Cosgrove, project director; project launch meeting 2013).

Research theme

Water Futures and Solutions, referred to here as WFaS, a flagship project of IIASA, is a multi-layered, cross-sector, stakeholder-informed, scenario-based assessment of the state of water resources and water demand using socio-economic and hydrological models. The WFaS Initiative will deliver water scenarios which combine qualitative and quantitative indictors across sectors and disciplines. Their policy relevance will be assured by including stakeholders in the scenario-building process and the

assessment of management options. As part of this general initiative, this research theme for the South African YSSP program aims at investigating some broad African water problems with emphasis on understanding and identifying robust options for managing extreme rainfall events under future socio-economic and climate change uncertainties, and how these options may improve water security in poor developing areas.

The outcome of this research project is expected to contribute to both scenarios analysis in order to provide an internally consistent picture of how water resources and water uses in different parts of Africa may develop during the 21st century under climate and socio-economic development uncertainties, while describing possible impacts, tradeoffs, and synergies of various management strategies.

Relevant skills

Climate change, climate variability, water security, hydrological modelling, environmental analysis, social dynamics and general interest in systems analysis, water management, water resource engineering.

Recommended reading

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SA-YSSP Research Theme 12

Water futures and solutions: Developing sustained solutions to improve urban water security in South Africa

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Background and motivation

This project seeks to explore innovations and solutions for improved water security in South Africa with a focus on urban setting in order to address the need for developing sustained solutions to improve urban water security. The continued increase of urban population and development activities present a complex demand on water resources. Such increase has resulted into the continued poor water quality and increased threat to water shortage within urban areas implying that the current strategies for utilising and managing limited and often deteriorating water resources require alternative solutions (Abbott et al. 2013; CRC 2014 & COGTA 2013). The lack of sustained strategies on efficient utilization of water resources in Africa and South Africa in particular remains a critical challenge especially in urban environment which faces increasing demand for water resources which needs to be used for various competing users (Winter et al. 1998; UN Water 2012). There is limited understanding of practical innovations and solutions to improve water security including the impact of urban development initiatives on urban hydrology systems in South Africa's context (Muller et al 2009; Douglas et al. 2009; EEA 2012; UN-Water 2008) . This project aligns the DST Grand challenge 3 on global challenges such as water security and with the IIASA research priorities on water futures and solutions. The practical implementation of the developed solutions will be demonstrated on how such solutions could improve water security in urban set up.

Research theme

The four of us plan to collaborate on a project where various analytical methods will be reviewed in order to develop a more practical and implementable method within urban settings. Students will be required to review and analyse data, interpret results and test practical applicability of such methods before suggesting alternative realistic methods in a given scenario. Detailed knowledge of urban hydrology and hydrogeology is essential but not a must at this stage. However, understanding the role of key stakeholders in the utilization and management of water resources within the urban setting is fundamental to inform realistic formulation and improvement of models that enhance water security and benefits of using, managing and sharing it among such stakeholders.

Relevant skills

Good background in environmental and/or water science is ideal but an interest in groundwater-surface water interactions in urban set up would be an advantage. Applicants should show expertise and critical knowledge identifying gap in existing knowledge or practice in order to conceptualize scenarios to inform practical solutions and initiate new research activities. Applicants should possess skills in quantitative and qualitative research designs, execution, analysis and interpretation of data.

Recommended reading

Abbott, J., Davies, P., Simkins, P., Morgan, C., Levin, D. & Robinson, P. (2013). Creating water sensitive places - scoping the potential for WSUD in the UK. CIRIA report no. C724, London, UK. ISBN 978-0-86017-733-3

CRC (2014) CRC for Water Sensitive Cities Annual Report 2012-2013. [Online] http://watersensitivecities.org.au/wpcontent/uploads/2014/01/CRCAnnualReport2013

COGTA, (2013) Towards an integrated urban development framework - A discussion document. Department of Cooperative Governance and Traditional Affairs, Pretoria, South Africa

Douglas, I., Alam, K., Maghenda, M., Mcdonnell, Y., Mclean, L. & Campbell, J. (2008). Unjust waters: climate change, flooding & urban poor in Africa. Environment and Urbanization 20: 187

EEA (European Environment Agency) (2012). Towards efficient use of water resources in Europe, Copenhagen, Denmark.

Muller M, Schreiner B, Smith L, van Koppen B, Sally H, Aliber M, Cousins B, Tapela B, Merwe-Botha M, Karar E & Pietersen K (2009). Water security in South Africa: Development Planning Division. Working Paper Series No.12, DBSA: Midrand, South Africa

Winter TC, Harvey JW, Franke OL & Alley WM (1998). Groundwater and surface water a single resource in U.S. Geological Survey Circular 1139, USGS website

UN-Water Report (2008). Status report on IWRM and water efficiency plans. Available at: http://www.unwater.org/2008/report/index.html

UN-Water Report (2012). UN-Water status report on the application of integrated approaches to water resources management. Available at: http://www.unwater.org/rio2012/report

Cluster 4: Population, Health, and Aging

SA-YSSP Research Theme 13

Demographic differential vulnerability to environmental change and climate variability in sub-Saharan Africa

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Background and motivation

The population-environment-development interface (or PED nexus as it is often referred to) is a highly multi- and inter-disciplinary field and one that transcends the boundaries of conventional disciplines in the social and natural sciences. The field is firmly imbedded in a systems approach to population and environment linkages and challenges. While development improves quality of life and leads to higher standard of living, it can have adverse impacts on the environment and livelihoods. Not only patterns of consumption and distribution of wealth and natural resources are unequal; environmental impacts are also distributed disproportionately across regions, nations, sub-national entities, communities and households. Apart from environmental change, another major challenge to wellbeing and livelihoods is climate change. The warning message from the recent report by the Intergovernmental Panel on Climate Change (IPCC) that the impacts of global warming are likely to be "severe, pervasive and irreversible" is alarming. That climate change is irreversible infers that inevitably humans have to adapt to these changes. However, exposure, sensitivity and capacity to adapt also varies considerably by population subgroups. This points to the importance of considering differential vulnerability across population groups when studying about development, environment and climate change. Research in this field thus usually is of huge significance to policy makers – both in the private and public sector - and has found its way to several legal and policy frameworks in South Africa and elsewhere. This context provides an opportunity for several unique case studies on the relationships between development, environmental change, climate variability and demographic differential vulnerability.

Research theme

Natural resources provide the basis for human survival and development. However, the increasing demand for these resources emphasizes the need for a coordinated approach to sustainable management of biological resources. The sustainable use and management of such resources requires an interdisciplinary approach and sound knowledge of each resource, as well as the ecological, socio-economic and demographic factors related to their use. Conservation policy and practices over the past few decades have indeed strongly emphasised the linkages between rural poverty and environmental degradation and, more specifically, the importance of reconciling the socio-economic needs and expectations of local communities with the objectives of biodiversity conservation and protected-areas management.

Meanwhile, climate change further exacerbates existing environmental stresses. While there is substantial ongoing research assessing the impact of future climate change on the Earth's physical systems, there are few systematic and comprehensive assessments on the likely impacts that climate variability will have on future human well-being. Certain socio-demographic factors such as poverty, poor health, low levels of education, gender inequality, declining family support for the elderly and unfavourable geographic location contribute to an increase in vulnerability. This is because population with these characteristics often lack political power to access resources necessary for disaster risk reduction and climate change adaptation. Given that not all people are equally vulnerable, demography can provide useful analytical tools to investigate differential vulnerability to natural disasters and climate change.

Accordingly, our main research objectives are to investigate: 1) the relationship between development and environmental change and how populations' livelihoods are affected by this relationship; 2) how the impacts of development and environmental and climate change vary across population subgroups; 3) the role of social networks, policies and institutions on development and managing impacts of environmental and climate change; and 4) the social and environmental prerequisites for sustainability in a specific context of development. Our project hence sets its focus on the intersection of development, demography and environmental sustainability in order to simultaneously address issues of resource conservation, adaptation to climate change, food security, poverty alleviation as well as gender equity in sub-Saharan African countries.

Relevant skills

1. Familiarity with statistical concepts and quantitative data analysis using statistical software e.g. SPSS, STATA, R, SAS.
2. Familiarity with systematic literature search and ability to conduct literature review independently.
3. Understanding of and proven ability to integrate two substantially different data sources (i.e. social and environmental/biological) into a single, holistic and coherent synthesis.
4. Additional skills on spatial analysis would also be desirable.

Recommended reading

Doocy S, Daniels A, Murray S, Kirsch TD. The Human Impact of Floods: a Historical Review of Events 1980-2009 and Systematic Literature Review. 2013. PLOS Currents Disasters. doi: 10.1371/currents.dis.f4deb457904936b07c09daa98ee8171a. Available at: http://currents.plos.org/disasters/article/the-human-impact-of-floods-a-historical-review-of-events-1980-2009-and-systematic-literature-review/

Duraiappah, A. K., International Institute for Sustainable Development, & United Nations Environment Programme. (2004). Exploring the links human well-being, poverty and ecosystem services. Winnipeg: International Institute for Sustainable Development.

KC, S., and W. Lutz. 2014. Demographic scenarios by age, sex and education corresponding to the SSP narratives. Population and Environment 35: 243–260. Available at: http://dx.doi.org/10.1007/s11111-014-0205-4

Smit, B., and J. Wandel. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change 16: 282–292.

Madulu, N. F. (2004). Assessment of linkages between population dynamics and environmental change in Tanzania. African Journal of Environmental Assessment and Management 9: 88–102.

Muttarak, R. and W. Lutz. 2014. Is education a key to reducing vulnerability to natural disasters and hence unavoidable climate change? Ecology and Society 19: 42. http://dx.doi.org/10.5751/ES-06476-190142. Available at: http://www.ecologyandsociety.org/vol19/iss1/art42/.

Pelser, A., Redelinghuys, N., &Velelo, N. (2013).Protected areas as vehicles in population development: lessons from rural South Africa. Environment, Development and Sustainability. doi:10.1007/s10668-013-9434-4. Available at: http://link.springer.com/article/10.1007%2Fs10668-013-9434-4

SA-YSSP Research Theme 14

Migration trends in post-apartheid South Africa

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Background and justification

Historically, migration in Africa and South Africa was heavily influenced by apartheid and colonial policies (Mabin, 1991). Influx control, the redirection of urbanisation to hidden urbanities and the policy of orderly urbanisation were key mechanisms in the hands of the apartheid state while influx control was also commonly applied in Africa. Core urban areas were viewed as being mainly "white areas" and the black population was to remain largely rural. The abolition of influx control in the mid-1980s (in South Africa) and the repeal of other apartheid legislation ensured freedom of migration and movement. This opened the core urban areas of South Africa to black people. As from the mid-1980s onwards, considerable numbers of new migrants flocked to urban areas (big cities and small towns). Despite these overall trends, an analysis of existing migration trends in South Africa remains limited (see Kok, Gelderblom, Oucho & van Zyl, 2005 as exception). However, the 2011 Census and databases such as the National Income and Distribution Survey allow more detailed assessments and forecasts to be made.

Research theme

Against the background sketched above, the aim of the research is to develop a detailed understanding of post-apartheid migration patterns in South Africa and post-colonial migration trends in Africa. More specifically, the following key questions are asked:

- What, according to the various censuses and other databases, are the internal migration flows in South Africa / Africa?
- What are the micromigration trends that can be detected between settlements and settlement types and even within settlements?
- What long-term forecasting and modelling can be done so as to provide policymakers with more precise information regarding the future?
- How do the internal migration patterns in South Africa differ from those of other African countries?

Methodologically, the research is dependent on two main data sets:

- Data from the various post-apartheid population censuses (1996, 2001, 2011) as well as various censuses in Africa.
- Data from the National Income and Distribution Survey, a panel survey with migration data for 15 000 adults across South Africa. The first survey was conducted in 2008 and subsequent surveys were completed in 2010 and 2012.

- A specific search of other databases will be conducted. The aim is to gather as many databases as possible with a view to triangulating the results.

In this process, the data from the various data sets will be used to

- fit gravity-type regression models to tease out drivers of trends for separate flow tables by age/sex/other individual variables where the origin-destination flow tables might exist;
- visualise the data using circular plots;
- estimate flow tables in non-census years by using any suitable regression model and by combining data from other sources where these are available;
- compare internal migration patterns in South Africa with those of other African countries; and
- The results will be contextualised against the historical patterns of migration and urbanisation in South Africa.

The project will be rolled out in four phases:

- Phase 1: Gathering all available research on post-apartheid migration patterns in addition to conducting a literature review of migration patterns under apartheid. This will, in the main, be done by the two supervisors prior to the official commencement of the project.
- Phase 2: Accessing the relevant databases. This will largely be done by the two supervisors prior to the official commencement of the project.
- Phase 3: Doing the statistical analysis (first month of the project)
- Phase 4: Writing at least two papers

Relevant skills

- Familiarity with statistical concepts and quantitative data analysis using statistical software, e.g. SPSS, STATA, R, SAS;
- Familiarity with specific population-modelling techniques;
- Familiarity with systematic literature search and having the ability to conduct literature reviews independently; and
- A thorough understanding of the historical patterns of migration in South Africa.

Recommended reading

Kok, P., Gelderblom, D., Oucho, J., & van Zyl, J. (2005). Migration in South and Southern Africa: Dynamics and determinants. Pretoria: HSRC Press.

Mabin, A. (1991). The dynamics of urbanisation since 1960. In M. Swilling, R. Humphries, & K. Shubane (Eds), Apartheid city in transition (pp. 33-47). Cape Town: Oxford University Press.

Statistics South Africa. (2006). Migration and urbanisation in South Africa. Pretoria: Statistics South Africa.

SA-YSSP Research Theme 15

New approaches to measuring ageing in South Africa

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[2]World Population Program, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Background and motivation

This project is designed to make use of the South Africa Study on Global Ageing and Adult Health 2007/8 (Wave 1). Nancy Phaswana-Mafuya (National Science Research Council) was the Principal Investigator this study. A link to this study can be found at: http://www.hsrc.ac.za/en/research-outputs?search=ageing&x=61&y=16&department=all&year=all&type=all&page-num=4

Warren Sanderson and Serguei Scherbov have been studying ageing and have published a number of papers on new approaches to measuring ageing (see references below).

Research theme

The three of us would like to collaborate on a project in which we apply those new approaches to South African data. Students will be analyzing the South African data on the basis of those new approaches. A detailed knowledge of those new approaches is not necessary at this point, but an interest in learning them is.

Relevant skills

Students who apply should have experience working with survey data on the computer. A working knowledge of some statistical software package, such as STATA, SAS, R or SPSS is required. Students should also be familiar with the analysis of data using EXCEL.

Recommended reading

Lutz W, Sanderson W, Scherbov S. The coming acceleration of global population ageing. Nature 2008; 451(7179): 716-9.

Sanderson WC, Scherbov S. Average remaining lifetimes can increase as human populations age. Nature 2005; 435(7043): 811-3.

Sanderson W, Scherbov S. Rethinking Age and Aging. Population Bulletin 2008; 63(4): 3-16.

Sanderson WC, Scherbov S. Remeasuring Aging. Science 2010; 329(5997): 1287-8.

Sanderson WC, Scherbov S. A new perspective on population aging. Demogr Res 2007; 16: 27-57.