



## Assessment format SENSE Institutes

### University of Twente – Faculty of Geo-Information Science and Earth Observation (ITC)

#### 1. Mission, vision and policy

ITC is in the midst of a decade-long reorientation away from its original mission as an independent educational institute, training students from developing countries in remote sensing and GIS, to a world-class, research-oriented university faculty, focused on leveraging remote sensing and GIS in the environmental sciences and related areas. Some aspects of ITC have proven easier to change than others, and it is easy to see the influence of the earlier mission in the ITC of today. ITC continues to attract large numbers of students from developing countries, where its reputation is unchallenged, and it continues to benefit from a staff that was originally selected for its expertise in training for all aspects and applications of remote sensing and GIS.

In addition to its relatively new responsibilities as a university faculty, ITC is also required to adhere to policy directives from the Dutch government. These now require ITC to focus on certain areas of the Global South, notably Asia and Africa; and to emphasize applications in areas of societal concern. Availability of funding also has its impacts, and ITC has weathered, with some success, a reduction in excess of 20% in its core funding over the past three years. In addition, a further 10% reduction is possible in only two years time. Funding is perceived as more readily available for applied research in these areas of societal concern, than for fundamental research in remote sensing and GIS. As a result, the research groups have been more successful at attracting funding through contract research and support for PhD students, than from international funders such as ERC and from the basic-research programs of NWO.

In reviewing each of the six research groups, we consistently probed for statements of vision that could provide each member of that group with strategic direction. In every case we found a lack of such a vision, and instead a sense of opportunism. In the current funding climate every group felt compelled to pursue nearly every funding opportunity, and to make hiring decisions based on maximizing these opportunities, for example by staffing in new areas of research that appeared to be well funded. In many cases the group's sense of its own domain seemed impossibly broad, with little strategic sense of long-term direction. We found ourselves first, noting the urgent need for a clear and credible vision of where each group wanted to be in say five years time and second, making the same practical recommendations: to identify an area of research lying within the current domain of the group, that would allow the group to focus its activities and build a world-class reputation in that area. This will be challenging, as some groups were still trying to achieve stability and direction following the mergers that resulted from the previous review in 2010.

We were disappointed to find that ITC as a whole does not have a shared and credible vision of where it wishes to be in the future and as a result, no plan to get there. However, we were reassured to find that the Dean is developing a vision and ITC does have a view of both what it is doing now (its mission) and its overall intellectual structure. It sees its mission as "Space for global development", a succinct linkage between its geospatial methods (remote sensing and GIS) and its application domains. Its departmental structure has appealing simplicity: two methods-oriented groups (EOS and GIP) underpinning four application-oriented groups: WRS ("water space"), NRS ("green space"), PGM ("urban space"), and ESA ("geo space"). "Jointly, these spatial domains cover the most relevant societal domains of GIS and Earth observation in developing countries".

In this new environment it is almost inevitable that groups will overlap in interests, driven by the desire to pursue every feasible source of funding. The two methods groups will seek application domains where funding can support their core interests, and the four application-domain groups will seek to leverage the strong expertise in methods that each has to varying degree. We heard repeatedly that, in this competitive environment, the collaboration between groups is not as strong as it might be, and that collaboration outside ITC can give proposals an edge with funding agencies that collaboration within ITC does not. Requiring each group to develop its own distinctive vision will help in several ways. It will emphasize complementarity of expertise within ITC, encourage groups to augment their own expertise, not by adding staff but by seeking collaboration, and allow each group to emerge as world-class experts in well-defined but manageable areas of strength.

Several research group specialities are undoubtedly at the cutting edge. Interest is being pursued in new methods of data acquisition: crowdsourcing, UAVs, and LiDAR. The PGM group is pursuing novel approaches to land registration. More important, perhaps, is the opportunity to find applications of high societal impact in the developing countries that have always been important to ITC and where ITC has a

unique advantage.

Importantly, we are not recommending that these research groups be reorganized but would anticipate that they would evolve to meet the needs of an ITC vision and subsequent strategic plan.

We were impressed by the dedication, tactical abilities and quality of the ITC leadership. They have achieved much since the merger with the University of Twente in 2010, not least, as we were informed, 'survival'. There is now an opportunity to step back and think where ITC could credibly be a few years from now and then plan how best to get there. However, in a week of reviews that first focused on the six research groups and then on ITC as a whole it was difficult for us to see how bottom-up and top-down were balanced in decision-making and direction-setting. Our recommendation for the development of strategic vision is intended to clarify and facilitate leadership in both senses: leadership from ITC management to motivate and direct, and leadership from each group to ensure that the six vision statements and their emerging strategic plans all have the full support of the entire research staff.

In summary, ITC has made great strides, and is to be congratulated on weathering well the various storms that it has had to confront in the review period. It is very much a work in progress, given the difficulties of achieving such a major reorientation in the space of only a few years. The next few years present significant challenges: first, to develop a culture of strategic planning; second, to continue the ongoing reorientation of ITC; third, to build stronger collaborations within ITC, with the University of Twente; and fourth, to weather whatever further budget cutting is required. At the same time there are many exciting opportunities: to champion the 'spatial dimension', to make the most of the University of Twente environment, to continue to play a major role in the nation's foreign-aid efforts, to take advantage of continuous technical innovation, and to aid in the solution of humanity's pressing societal problems.

## 2. Research quality

ITC is known around the world for its training programs and for the research of several of its internationally prominent staff. Indeed, it is unusual to attend any remote sensing or GIS conference in the developing world without encountering at least one member of ITC staff and several ITC *alumni*. This reputation has been built over many decades, and represents a very substantial asset. On the other hand ITC is much less well known in the Netherlands, and its relationship to its new parent institution, the University of Twente, is still, after only four years, a work in progress. Other organizations within the Netherlands challenge ITC for leadership in the remote sensing and GIS fields, and may well be better known nationally and within Europe. Of these, Geodan is perhaps the best known, though unlike ITC it is largely invisible outside Europe.

The publication rates of ITC are generally very satisfactory. In our recommendations for individual groups we frequently suggested a strategy of moving where feasible, the *balance* of publishing to the domain science journals and away from the remote sensing and GIS journals, on the grounds that the former tend to have higher impact factors and to be more widely read. But overall we have little concern for the quality of ITC research as reflected in bibliometrics.

Research infrastructure appears to be excellent in certain areas, including spectroscopy, soil chemistry, and related areas. Of more general concern, however, is the state of the IT infrastructure. Great strides have been made internationally in recent years in advancing IT infrastructure as it relates to the distribution and sharing of large geospatial databases. Esri is investing in real-time access to imagery from platforms as convenient as the smartphone, while GEOSS has developed very effective methods for archiving and dissemination, and the US Geospatial One-Stop is able to harvest metadata robotically from distributed servers. Yet ITC appears to be falling behind these developments. As a leading center for remote sensing and GIS one would expect a substantial investment in data science: in curation, interoperability, metadata, provenance, visualization, mining, and all of the other concerns of the rapidly emerging world of 'Big Data'. Instead, ITC's current technology in data management reminded us of the 1990s (e.g., the Alexandria Digital Library of 1993), with its emphasis on acquired and locally stored data, and access via the sensor rather than geographically. We asked several groups how the observational data they acquired was managed, and were told that every researcher essentially managed his or her data; a very unsatisfactory approach given the growing importance of data, and data science, in world-class research. More broadly, we missed the kind of strategic planning that is necessary today in the rapidly evolving world of IT, and essential for any group that wishes to hold onto an international reputation. It would be good if such strategic planning could be made in the context of the pending move to the University of Twente campus, and could take advantage of the logistical, financial, and economy-of-scale opportunities such a move offers. Finally, the actual inaccessibility of ITC's data to outside users seemed at odds with its expressed "open data" policy.

### **3. Societal relevance**

ITC has an excellent record of relevance in its traditional role of training students from the developing world in remote sensing and GIS. Countless projects in the developing world owe their success and impact at least in part to ITC. Its ILWIS package, now distributed through 52 North, is an excellent asset that could be doing more to promote the ITC brand internationally. ITC has branched out into the four application domains represented by four of the six research groups, and built a record of strong, socially relevant research in each area.

ITC is hampered however, in achieving the same societal relevance in the developed world, and in the Netherlands. It is unable to recruit Dutch students into its PhD program, though we understand efforts are under way to change this regulation. ITC's relevance could be enhanced by a program of development of strategic partnerships with highly regarded centers, both nationally and internationally, and by exploiting the new intellectual opportunities offered by merger into the University of Twente. The social sciences, for example, are often the key to increasing the societal relevance of projects in the environmental sciences, but are an area where ITC is weak. However, there are new opportunities on the main campus of the university, where ITC will be moving in a few years. It would be helpful to conduct a strategic search at both the University of Twente (e.g., within the Academy of Technology, Liberal Arts and Sciences) and other centers in the Netherlands and more broadly in Europe, in order to identify suitable groups and departments, rather than leaving such networking to individuals.

### **4. PhD policy**

ITC has a large and impressive community of graduate students. We were very impressed with our interactions with them, and with the posters and presentations they had prepared. ITC students have a long tradition of rich cultural interaction, and benefit enormously from the maturity and diversity of the group. On the other hand we heard some frustration that they are generally not able to experience and learn about the Dutch culture, in part because of the lack of Dutch students.

We sensed that the PhD students could take a larger role in organizing intellectual activities. A student-organized conference can often be very rewarding, giving students an opportunity for peer-to-peer interaction that is often difficult in a structured program. Students might enjoy organizing sessions of 'lightning talks', or organizing seminars on topics of interest.

SENSE offers many services to assist PhD students, including a Web service to identify requirements and monitor progress, and the A1 course. We understand that all ITC students take the A1 course, but sometimes and for various reasons not early enough in their programs. We also heard some variation in the degree to which students feel part of SENSE, and take advantage of what it has to offer.

In our meetings with students several concerns were expressed about the student-support services offered by ITC, including issues over IT and in particular, housing. In a short visit we were not able to probe deeply, or to determine whether consensus exists on any of these issues. While we noted a general sense of student satisfaction, in our view it would be desirable if ITC's strategies and policies with respect to student life, and its mechanisms for listening, monitoring, and responding to student views were reviewed.

It has always been difficult to establish uniform standards of quality for the PhD, given its advanced nature. Peer review through the appointment of external examiners is far from foolproof, but has perhaps been the most important instrument for maintaining uniform minimum standards. Recently, however, there has been a tendency to emphasize published papers, and to see the PhD as a collection of some specified number of papers. Peer review is involved, of course, because publication is in refereed journals. At the same time placing the emphasis on a count of published papers has its own dangers, in encouraging unduly early publication and a culture of "least publishable unit". Moreover, we heard wide variation across SENSE in the number of papers required by a supervisor (promoter), before thesis submission was possible, and also in whether a standard minimum count existed. Quoted counts from ITC alone ranged from zero, to three in press, to seven published. (It is impossible also to ignore the effect that such policies have on "reviewer burnout", since publishing seven papers must involve at least 21 invited reviewers!). We do not have a position to recommend. However, a large proportion of ITC graduate students fail to submit within five years of study (average is over five years). This would suggest that ITC work with the University of Twente (who award the degree) to clarify its policy on the minimum level of peer review required for thesis submission approval by a supervisor.

### **5. SWOT**

In its own SWOT analysis ITC proposed several strategies to address perceived weaknesses and threats, and to build on strengths and opportunities. The following comments refer directly to the analysis, on p10 of ITC's self-assessment.

Weakness: limited experience with entrepreneurial activities, and the current trend towards more collaboration with private partners.

ITC is ideally situated for collaboration with the private sector, especially in developing countries. Given the University of Twente's acknowledged strength in enterprise activities we strongly endorse its proposed strategy: "Start our own research-based start-up companies (both in the Netherlands and in target countries)". ITC currently is a partner in 52 North, but could do more to build partnerships with existing remote sensing and GIS companies in the Netherlands and Europe more widely. We were told that the adopted strategy of "open-source, open data" precluded benefiting financially from ITC's research through patents, royalties, etc., which seemed to us a rather narrow interpretation.

Threat: base funding insecurity and Dutch political developments.

Weakness: gaps in expertise (e.g., engineering and health) and ineffective communication of policy-relevant outcomes.

Threat: development policy is too much focused on Ploumen themes, and GEO-ICT is considered ICT only.

As suggested earlier, we believe that vision-led strategic planning and the focusing of research group interests will help to raise the visibility of ITC, and encourage collaboration with complementary groups elsewhere. Collaboration of this kind seems to us the best strategy for dealing with base-funding insecurity. By way of contrast, the filling of gaps in expertise within ITC is likely to be an expensive and ultimately ineffective approach.

We were not able during our short visit to probe the strength and effectiveness of ITC's arrangements for public communication. Just as an organization of this nature requires an IT strategy that provides up-to-date infrastructure, similarly it is necessary to work strategically to enhance the organization's communication and public-affairs capabilities. An important element of this will be the careful positioning of the ITC brand (international focus, world-wide reputation, narrow in scope) in relation to that of the University of Twente (national focus, strong reputation in the Netherlands, broadly based) for the benefit of both. However, we did explore the visibility of ITC publications within the academic community and more widely. We were informed that for many years the research group name and then the ITC name appeared after the author's name on a research publication. Currently, however, we were informed that the research group, ITC in brackets, and then the University of Twente appear after the author's name. Given that research publication is probably the most powerful mechanism at ITC's disposal for raising its national and international profile it is suggested that thought be given to placing only ITC and the University of Twente after the author's name, omitting the research group.

We did wonder to what extent ITC and its spatial expertise were understood in the University of Twente and more widely. The notion that "GEO-ICT" is just ICT is of course naïve, but very appealing to those needing to cut costs and to funding agencies. To fight it requires a constant commitment, and the ability to marshal convincing arguments. Efforts to build support for "spatial thinking" and "geographic information science" stem from exactly this problem, and have been under way now for two decades. Following the example of Harvard or UC Santa Barbara, one might convene a committee of senior academics from across the University of Twente to explore these issues and identify programs that can illuminate the cross-cutting nature of spatial thinking. It might also be strategic to consider the same kind of activity between institutions, perhaps across the Netherlands or within SENSE.

We were most impressed by the esprit de corps of ITC and the genuine pride shown by staff and students in their organization. This pride is the product of many influences; these include (among others): successful history, strong social mission, international scientific and technical reputation, cultural and social diversity, flat management structure, sense of identity, purpose-built and architecturally interesting building, common social and dining space, close proximity of reasonably priced student accommodation, and an easy working style. We were surprised by two things: first, that this significant strength of ITC was not noted in the documentation and second, that a potential risk to this strength, the imminent relocation to the University of Twente, was also not noted. While it is clear that joining a larger academic community would bring many advantages we would suggest that ITC focus on the cultural/social as well as the physical/financial implications of the move in order to mitigate the risk to this significant but intangible ITC strength.

## **6. Recommendations / suggestions on improvement**

- Develop a strategic plan for ITC around a common and shared vision: to become by, say, 2020 the leading research entity in Europe, in a well-defined area or areas that fall within ITC's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.
- Develop vision-led strategic plans for each research group that feed into the development of the strategic plan for ITC as a whole. As recommended in our research group reports there is a need to choose a research focus, within the current domain of each group. This focus should guide future

recruitment, help to identify the specific strengths of each group, and provide a basis for complementary collaboration with other groups within ITC and elsewhere.

- In conjunction with (2), conduct systematic reviews of the potential for collaboration with groups within the University of Twente and within other Dutch institutions. Special emphasis should be placed on groups that can provide expertise in social science. Ideally this work needs to be completed prior to the relocation of ITC to the main University of Twente campus.
- Initiate a process of strategic planning of ITC's IT infrastructure, with a view to (i) identifying generic areas that need to be sector leading and generic areas that could be sector average and (ii) bringing IT to the level expected of a leading center of remote sensing and GIS. Develop a data policy that addresses all aspects of (big) data science, with institution-level management of ITC's data resources.
- Work with the PhD student body to improve opportunities to discover Dutch culture, perhaps taking advantage of the opportunities offered by the pending move to the main University of Twente campus.
- Encourage the PhD student body to initiate and organize student-led activities that enhance the intellectual and scientific aspects of student life.
- Clarify ITC's policy on the minimum level of publications required for thesis submission, in consultation with the University of Twente and SENSE.
- Initiate a process of strategic planning of ITC's public-affairs and communications activities, with the aim of improving national and international public perception of ITC and in particular, ITC's societal relevance.
- Convene a committee/working group of senior academic staff within the University of Twente to explore the interdisciplinary opportunities of spatial thinking and GIScience.
- Plan carefully the cultural/social alongside the physical/financial implications of the move of ITC to the main University of Twente campus.

**Programme 34: Earth Observation Science (EOS)**

Leaders research group:	Prof. G. Vosselman, Prof. A. Stein	
Research input 2013:	tenured staff:	2.3 fte
	total staff:	13.9 fte
Assessment scores:	Scientific quality	4.5
	Productivity	5
	Societal impact	4
	Viability	4

*Scientific quality*

The scientific quality was internationally excellent with some areas world leading. The two Professors in the group are both undertaking research that is at the cutting-edge of their fields. The past few years have seen the impact of this research rise from 'above world average' to 'very good world impact'.

There is potential to publish in higher-impact journals if undertaken in partnership with others – in general, the top journals in the application domains tend to have higher impact than the specialist journals in remote sensing and GIS.

The potential for the future is excellent, given the focus on topical areas such as low cost sensors, 3D terrain simulations, UAV and SLAM.

*Productivity*

The productivity of the group is world leading and increasingly focused on publications in refereed journals. The majority of these are in the geo-informatics journals and as noted above, there is an opportunity in the future for more joint publishing in higher impact discipline wide journals (e.g. health, planning).

Research income and PhD student numbers are both high and increasing. The international profile of this group is greatly enhanced by journal editorships and the willingness of its members to contribute to issues of global relevance.

The research of this group is relevant to the other five research groups at ITC and the potential for greater within-ITC partnership is substantial.

*Societal relevance*

The research is applied in several, clearly documented, societally relevant areas with a growing strength in health. The impact of this research, both in terms of the interaction with stakeholders and effect on society, is of international standards of excellence.

Research in developing countries (e.g., Ghana) is a clear strength. Also notable are the group's contributions to practice in laser scanning, specifications for digital elevation models, and 3D data capture.

Issues of data quality are often difficult to present to a broad audience. Much of the research in this area is highly mathematical and thus inaccessible to many communities, despite their evident need for such information. The research might be made more accessible through easy-to-use tools, offered perhaps through the ILWIS platform, plus online tutorials, examples of best practice, and methods of visualization that might be developed in partnership with the GIP group.

*Vitality and feasibility (viability)*

The group is small (8 faculty, 2.31FTE), well managed and has the vitality and feasibility one would expect from an internationally excellent group in this field. The group is clearly a stable pillar of ITC, with a carefully managed balance between fundamental research and the more easily funded applied research. They have gained more coherence and focus since the last review and this was welcomed.

The group presented a very clear explanation of where they are *now* (2014). The challenge for the next stage of the group's development is to identify a clear and compelling view of *where they wish to be* by the time of the next review (2021?). This will enable the group to identify clear strategies to get there.

This move from 'good to great' is in the grasp of this group if they choose to focus on a future vision. They could, for example, be Europe's leading centre for research on the quality of geo-information.

#### *Recommendations*

- Develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.
- Develop further the opportunities for within-ITC partnership for the benefit of both ITC and EOS.
- Seek opportunities to publish in higher impact journals in partnership with others.

**Programme 35: Geo-information Processing (GIP)**

Leaders research group:	Prof. M-J. Kraak	
Research input 2013:	tenured staff:	2.2 fte
	total staff:	14.1 fte
Assessment scores:	Scientific quality	4.5
	Productivity	4.5
	Societal impact	4
	Viability	4

*Scientific quality*

The group resulted from the merger of two groups in 2010, a merger which “required re-orientation of research”. Today the group is integrated around a simple model that combines five interests: modelling, analytics, geo-visualization, data organization, and the intriguingly named “cloud and crowd” covering user-generated content and computing in the cloud. The group has an international reputation, approaching a world-leading reputation, in several of its areas, most notably geo-visualization, which it is able to sustain despite its very limited size. However it would be naïve to think that it can achieve or sustain such a reputation in all five areas, so we probed to see if the group had a clear vision of a sustainable future. Moreover, as it perceives itself as under increasing pressure to find funding in application domains, and as competition for the kinds of funding that ERC and NWO directs at fundamental research becomes increasingly intense, it is essential that the group not attempt to add expertise in new areas, but to cultivate a reputation as the “go-to” collaborators in certain well-defined areas. For example, many of the projects for which the group might compete for funding will require expertise in the social sciences, in human-subjects evaluations of geo-visualization techniques. But it makes much more sense to seek this kind of expertise through collaboration rather than by adding it to an already stretched academic staff complement.

The group has identified spatio-temporal analytics as a major focus. There is much world-class research to be done here, especially in the context of geo-visualization and crowdsourcing, and an abundance of fertile areas of application. We were surprised to see “Spatio-temporal domain becomes mainstream which leads to more competition” as a threat. Greater confidence in the group’s own strength would be appropriate, especially if it aspires to continental or global leadership.

There is potential to publish in higher-impact journals if undertaken in partnership with others—generally, the top journals in application domains have higher impact than the specialist journals in remote sensing and GIS.

Besides fundamental research, the group also sees the development of tools as part of its contribution to high-quality scientific activity. The ILWIS GIS, which has been developed at ITC over many years, is now maintained and distributed as an open-source package through the company 52 North, in which ITC is a major collaborator. We wondered how effectively ITC is able to leverage its investment in ILWIS, and noted that the front page of the ILWIS Web site makes no mention of ITC. Given the statistics on ILWIS distribution it seems ITC is missing a major opportunity here to strengthen its reputation in geospatial technology. At the same time, we were impressed by the team’s ability to justify software development as a contribution to science. Similarly, the group feels that it is necessary in today’s climate to commit to projects with little scientific content, and acknowledges that this is a potential weakness.

In summary, the group’s research is world-leading in certain areas and internationally excellent in much of the remainder, but focus will be needed if the next review is to rate the totality of its research as world-leading and assign the highest possible grade.

*Productivity*

The productivity of the group ranges from internationally excellent to world leading. The bibliometrics are generally excellent for the group. The rate of PhD graduation is low relative to the size of the current group, but can be explained by the earlier ramping up of student numbers that has yet to work its way through into the graduation rate. Given the nature of the group’s work one might have expected a stronger record of patent application, and we were unclear as to whether the group has been responsible for any spin-off companies (a comment that can be made about ITC in general).

### *Societal impact*

The group are achieving internationally excellent levels of impact. Given the group's focus on fundamental research and on tool development it is likely that its impact on society will be indirect rather than direct. However there are several excellent examples of direct impact: the requests for work by the International Court of Justice (mapping border conflicts), World Bank and the UN Cartographic Unit and local governments and ministries (e.g., in Georgia), as well as practical contribution in development of sensor Web standards via the Open Geospatial Consortium, are all examples of direct contribution. ILWIS has had major impact, so it is important that ITC's role in its development be given greater emphasis. The group's model of its "geoinformation production chain" is an excellent basis for applied and domain-specific research, but as noted earlier it is essential that this be achieved through collaboration, rather than through limitless stretching of the group's limited expertise. We heard that many funding sources emphasize collaboration outside ITC, and that collaboration within ITC is less attractive in this context. Nevertheless the group is one of the two that is more defined by methods than by application domains, and this surely makes the group an essential collaborator in many ITC projects. In that sense it was surprising to see "insufficient internal (faculty) cooperation" listed as a threat.

### *Vitality and feasibility (viability)*

The group are very well equipped for the future. We were impressed with the group's achievement in merging two of the 2010 groups into a harmonious and homogeneous whole in the space of four years. Nevertheless, its long-term viability depends on how well it is able to balance the need for external funding, with its associated opportunism and "mission creep", with the need to achieve a world-class reputation for a well-defined line of research.

The group did not have a clear view of where they would like to be in the future and so an evaluation of their route was problematic.

The self-assessment listed "Lack of collaborative publication policy" as a weakness, and we understand that this stems from concerns within the group. But we wonder if it makes sense for a group of this size to be indulging in introspective policy formulation.

### *Recommendations*

- Develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.
- Take steps to ensure that ILWIS is strongly associated with the ITC brand, and that ITC reaps appropriate returns for its decades-long investment in this toolset, and for any future investments in tools. When investments are made in tools, ensure that besides supporting scientific research, such developments also contribute to the body of scientific knowledge (for example, by reporting research discoveries on the user experience or on software architecture).
- Seek opportunities to publish in higher-impact journals in partnership with others.

**Programme 36: Urban and Regional Planning and Geo-Information Management (PGM)**

Leaders research group:	Prof. M. van Maarseveen	
Research input 2013:	tenured staff:	4.7 fte
	total staff:	40.5 fte
Assessment scores:	Scientific quality	4
	Productivity	4.5
	Societal impact	5
	Viability	4

*Scientific quality*

Since the establishment of the new and stable leadership, the group has made great strides in defining and advancing their research agenda and complementing the strength in capacity building. The interdisciplinary science mission related to social and geo-information science / technology, with an ambition to incorporate the perspectives and concepts from humanities, is commendable. The group's intention to accomplish this goal through collaborations with scientists from UT and other institutions in The Netherlands and worldwide is realistic, as it would be difficult to provide such a broad and diverse expertise internally.

While not necessarily new as an idea, the interdisciplinarity and the socio-technical approach have not been effectively achieved and mainstreamed in the discipline, and the group is well positioned to fill this gap. This, however, would be difficult to pursue in an environment which praises such endeavours, but to a large extent operates through established disciplines and channels. Under these circumstances, the group is encouraged but also will be challenged to assert their uniqueness and contributions to a broader community of peers. This community could be both disciplinary and cross-disciplinary, and it would be useful if the unit decided who the most relevant peer group would be.

The group has maintained the core staff research capacity (even with some small decrease and turnover) and has significantly increased the number of PhD students and visitors (along with related funding), contributing to overall doubling in FTE available for research. The group is doing well in ensuring the balance between the capacity building mission and increasingly research-oriented activities, but is also stretched with the increasing demands in both areas of operations and given the extensive disciplinary portfolio.

The group is well embedded and successful in obtaining funding nationally and internationally and connecting to institutions at all levels and various scope – north and south – based on complementarity of interests. In addition to SENSE, the graduate programme is part of UT graduate school and also UNU. The supervision of students, quality control and monitoring has been enhanced in the process of changing funding environment and publishing expectations from PhD students. Staff are recognised with awards and keynote invitations and journal editorship, membership in national, European and global societies and networks.

*Productivity*

The group has made an excellent increase and diversification of output and impact since 2007. The staff continue to pursue conference papers and publishing of PhD theses, while the publications and reports intended for a general public readership, which are an important outlet to ensure the societal impact, have been maintained with some fluctuation. Social science output is the key strength; the publications, however, are across the disciplines – as expected from the inter-disciplinary agenda of the group. PGM has achieved this level of productivity by strategically redefining their research program, and employing a new strategy to leverage research support for increased productivity from post-doctoral researchers and Ph.D. students.

The PGM has also made notable progress in generating external funding. Over the review period the research funding has increased by nearly 200% and the funding from contract research has increased by nearly 300%. Overall, the PGM has achieved a high level of productivity and appears to be on a trajectory to continue to improve and stabilise the achievement as measured by the relative impact, with expected additions of new faculty members this year and next.

*Societal relevance*

The unit's general aim is well established -- contribution to the global development agenda by focusing on urban poor and data poor environments by developing methodologies for improving local collaboration and communication in understanding, problem-solving and decision-making. The group has a strong emphasis on societal issues which guide their engagement in both research and capacity building. The

foci which bridge the research and capacity building include: strengthening of land governance in the global south; informing policy on urban development; and promoting stakeholder involvement in urban decision-making. These foci are highly relevant to contemporary issues and challenges, especially in developing countries seeking to achieve sustainability in the context of poverty and rapid urbanization and could be more focused in order to reinforce the methodological element and the group's interest in developing pragmatic socio-technical solutions. The PGM pursues its work in collaborations with national and international partners, including professional organisations (FIG, EADI, NAERUS, UN Habitat, World Bank, UNEP, FAO; Dutch Cadastre) and local agencies and groups (governmental and non-for profit). From the program's self-assessment, it appears that stakeholder involvement is a genuine and routine aspect of their activities, which asserts the group's social relevance. Among the national projects, PGM's involvement in development of ISO 19152 Land Administration Domain Model stands out. PGM uses creative knowledge dissemination methods, including education, media and software tools (in addition to publications for general public / non-academic).

#### *Vitality and feasibility (viability)*

The PGM appears to be a vital and healthy department poised for continued productivity and international recognition. Restructuring and adaptation to the new environment (UT) and developing a joint mission has laid the foundations for the unit's success. The group is becoming stable and coherent, has diversified its resource base, and is very active in their engagements (possibly overstretched). There appears to be a recognised tight staffing situation and no support staff. The expected growth in tenured staff with strategic selection of expertise should contribute the needed additional energy and expertise. While the age profile of the faculty includes a majority of senior faculty, the program will benefit from the approval to recruit three additional faculty members.

The unit is well aware of its context and issues, with continued attention to further development and performance. The PGM has a proven ability to attract research funding, through governmental support and contract research funding. The self-evaluation report notes a threat of funding instability. Based on recent advances in research funding and publications, and an entrepreneurial culture, it appears that the PGM is likely to endure temporary uncertainties in funding, while seeking funding from a diverse pool of sponsors.

#### *Recommendations*

This is a diverse but complementary and cohesive group with an ambitious interdisciplinary agenda, viable capture of research funding and high productivity. It is commended and encouraged on its current interdisciplinary path and assertion of its uniqueness and value. Given the already substantial breadth of applications, the group is correct to express the need for selectivity and in fact careful framing of its research foci to ensure continued success with funding, publications, and achieving a clear overarching mission. The new hires should be selected carefully to ensure the coherency of the group's work and it is not obvious that the specific topic in climate change would do so. The capacity building work and contract work remain an important part of the group's portfolio and are well aligned with the strategic research foci. The group is connected and well-known internationally for its capacity building and educational activities, and is on a clear path to an excellent reputation in interdisciplinary endeavours and socio-technical approach to the fields of geo-information, land management and urban development. However, given the extensive and interdisciplinary nature of the three fields which could lead to many possible applications, the balance between the breadth and depth would be important to keep in check. The PGM is therefore advised to:

- a) continue efforts to integrate the three existing fields and research foci with an overarching focus which will ensure the greatest synergy, unique expertise and increased potential for externally funded research;
- b) pursue the inter-disciplinary and socio-technical approach by carving and maintaining a unique expertise and contribution, by complementing the internal strengths through collaborative engagements with social sciences and humanities, rather than attempting to develop the social science and humanities expertise internally; and
- c) use the approved future positions and hiring process to strengthen the Department in the selected synergy of the three existing fields (and in this regards, adding climate change domain and expertise is not an encouraged option).

To ensure its advancement and continued success, the PGM unit would need to develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Further, the group would define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.

**Programme 37: Earth Systems Analysis (ESA)**

Leaders research group:	Prof. F. van der Meer Prof. V. Jetten	
Research input 2013:	tenured staff:	3.8 fte
	total staff:	22.3 fte
Assessment scores:	Scientific quality	4
	Productivity	4.5
	Societal impact	4.5
	Viability	3.5

*Scientific quality*

The group resulted from the merger of two groups in 2010, one focused on geothermal energy and the other on natural hazards and is now performing at international levels of excellence. The merger is still clearly a work in progress; as the self-assessment notes, the group is "on its way to integrate these themes". The self-assessment presented a diagram of this integration, with geothermal energy at the base, ascending through geodynamics and mineral and soil predictions, to urban disaster risk management, rural hazards, and food security, to climate change and extreme weather at the top. This gives the group a very broad domain, and within that domain it has achieved remarkable success in the quantitative metrics of scientific accomplishment: publications, research funding, and growth in the PhD program.

This breadth of interest is eminently suitable to training, but at the same time it acts as an impediment to the establishment of a world-class reputation for research. Instead, the group is known for its individual research contributions, rather than for an outstanding reputation in any one area. Future planning in this environment is difficult, since the lack of a clear vision makes it impossible to strategise or to make decisions on long-term issues such as the recruitment of academic staff. Some areas of interest clearly overlap those of other groups: PGM, for example, is also proposing to hire a specialist in climate change, and has expertise in land management; while food security also shows up in the interests of NRS.

There is potential to publish higher impact journals if undertaken in partnership with others.

The environment is a complex system and its problems are consequently complex and difficult, requiring collaboration between many disciplines. No one group can hope to include all of the interests needed to solve even the simplest problems; instead, environmental science is characterized by a rapidly changing network of collaborations between groups, each of which is eminent in its own chosen domain. ITC offers the opportunity for a rich set of collaborations, between groups, with other groups in UT, and internationally. It was good to read in the self-assessment that ESA is "just starting" to exploit the potential of collaboration within UT; the proposed move to the main campus should make this easier than in the past. In its self-assessment the group noted that the "network in the Netherlands is not used to its full potential", seeing this as a threat. Collaboration with the social sciences is critical, as the human dimensions of the Earth system become more and more important. It is clear that the greatest potential for effective collaboration on social issues lies outside ITC.

In short, the group is producing internationally excellent research in certain domains. Its lack of a clear vision and focus will be an impediment, however, if it is to continue to improve its scientific quality in the future.

*Productivity*

The productivity of the group ranges from internationally excellent to world leading. The bibliometrics are generally excellent for the group. The rate of PhD graduation is satisfactory relative to the size of the current group, which has remained stable through the review period. As the group develops one would expect the total number of papers in refereed journals to stabilise or decrease as the number in high impact journals increases.

*Societal impact*

The research makes a societal contribution that is internationally excellent. In addition there are some areas that make a world leading societal contribution. The group's work is eminently suited to a strong

impact, especially in hazards, and to significant impacts in the areas of the Global South that are identified by the Dutch Government as of special interest. At the same time the methods of outreach that are available to a group of this size are limited, so it is important that the group strategize about the best methods given its resources. For example, is the group making the most out of the potential of its *alumni*, who are in many cases in positions of growing influence?

Care will be needed not to build the future of the group on the availability of some excellent PhD students to generate a wide range of geographically based case studies. Such studies can so easily replicate many of the scientific methods without generating the new principles and concepts that will lead to a higher research profile. There would be benefit in linking these studies link to local stakeholders and so deepen their impact.

#### *Vitality and feasibility (viability)*

As reviewers we were concerned about long-term viability of the groups ambitious research programme, given the issues identified earlier. Particular concern was expressed about the level of contract grants that resulted in applied, in-place applied work and also the long-term stability of overseas funding via PhD studentships. We think the group will need to work hard on strategic planning in the next few months, if it is to make the most of its potential, both internally within the group, and externally within ITC, UT, and the broader scientific community. The current aspiration, expressed in the self-assessment report, is overly ambitious given current realities and reasonable expectations about the future. Similarly, the senior ITC administration's vision of this group's role, as providing the institutional cover for an important component of "geo-space", is also overly ambitious. Parts of this current aspiration are not sustainable, and other parts need to be complemented by proactively established linkages. Moreover, it is important that these linkages be with groups that have established reputations for high-quality research.

#### *Recommendations*

- Develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.
- Consider the benefits to ESA and ITC more widely, of a different organisational structure that does not divide what is a world leading strength in remote sensing.
- Seek opportunities to publish in higher impact journals in partnership with others.

**Programme 38:****Natural Resources (NRS)**

Leaders research group:	Prof. A. Skidmore	
Research input 2013:	tenured staff:	3.9 fte
	total staff:	23.2 fte
Assessment scores:	Scientific quality	4
	Productivity	5
	Societal impact	4.5
	Viability	4

*Scientific quality*

The group produces generally very high quality science of international levels of excellence, indicated by a very good, though slightly declining, world average impact. The *h*-index scores of many individuals in the group are very impressive and increasing (e.g., two over 30). It was noted that the group had produced some highly cited papers during the review period but also that the contribution was very variable across the group's members. There is potential to publish higher impact journals if undertaken in partnership with others, since impact scores of journals in the specialist remote sensing and GIS fields tend to be lower than those in the top journals in applied domains.

The large number of visitors from home and abroad attests to the group's international reputation.

The group had a large and stable number of PhD students, coupled to equally stable research income. A future challenge will be to decide what mix of funding to seek (i.e., exceptionally competitive NWO and ERC funding vs international project funding). The choice will be dependent on the development of a long-term vision of the group.

The group's emphasis is on vegetation and they develop and use a range of remote sensing techniques. It was clear that the group has excellent skills, tools and experience to support this. Because vegetation is in some ways the driver of the entire environmental system, the group is potentially able to tackle an enormous range of projects. In Chapter 1 of the report there is mention of "wildlife and livestock behaviour", "food security through crop production", "forest biomass", "biodiversity", "land cover change and landscape modelling". This kind of breadth makes sense in an environment in which research groups need to pursue funding opportunities as they arise, and also in an institution oriented to training, but it is unlikely to give the group an international reputation as the go-to experts for collaborative ventures. "Sustainable landscape" is another uniting theme of this methodologically strong group that opens funding doors but in the long run may be too broad to be distinctive. This kind of opportunistic breadth also has uncontrollable effects on the workload of academic staff as it encourages a culture of saying "yes" to everything.

*Productivity*

Productivity across a very wide range of research activities is at a world leading level of excellence. Publication in refereed journals has increased markedly and although the overall level of funding is not increasing, it remains high. The group benefits from several members who have developed innovative methods in remote sensing and quantitative modelling and an exceptionally productive leader with a world-leading reputation for the quality and relevance of his research.

The majority of the publications are in remote sensing or allied journals and there is an opportunity for more joint publishing in higher-impact discipline-specific or major science journals. The choice between, for example, a *Nature* paper vs an environmentally relevant contribution to sustainable development in a developing country, will be dependent on the long-term vision of the group.

The international profile of this group is greatly enhanced by journal editorships and the willingness of its members to contribute to issues of global relevance.

*Societal impact*

Remote sensing of vegetation is applied in several, clearly documented, societally relevant areas with a long-term strength in the spatial distribution of biodiversity in general (flora and fauna). The impact of this research, in terms of the interaction with stakeholders and effect on society, is generally of international standards of excellence but with some examples of world-leading excellence.

Research in developing countries, notably in Africa, is a clear strength (e.g., wildlife) and the increasing focus on issues of concern to Europe was noted. The training of large numbers of young scientists from all over the world, and notably developing countries, is a main characteristic of the group and an important part of its societal impact. Like other ITC groups, the tradition of a developing-area focus is increasingly challenged, and effort needs to be made to make the group's work more relevant to the problems of Europe and the Global North.

#### *Vitality and feasibility (viability)*

In the long term, we are concerned that such a broad distribution of strengths will not lead to the kind of unique and distinctive reputation that will be needed if the group is to achieve sustainable viability as a world-leading operation and if it is to compete for the most prestigious kinds of research funding. It is unlikely that its size will increase by more than a few positions in the next few years, so its viability will have to be achieved with a small group, something that can only be done if the group shares a common vision of purpose that is built around a well-defined and focused area of strength. As it stands, we feel that the areas of strength recognized by the group – remote sensing of vegetation and landscape sustainability – are too large and diffuse for this to be achieved without even greater levels of collaboration. Moreover the complexity of environmental problems is such that no group, however large, can succeed without strong and overtly strategic collaboration. In this environment, if expertise is needed in some new area, such as social science, it is almost always better to find it through collaboration than by adding more diversity to an already highly diverse group.

#### *Recommendations*

- Develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of strong and overtly strategic links with complementary and similarly ambitious groups.
- As part of that strategic plan, identify the steps that need to be taken to transform the traditional focus on developing areas into a truly global focus.
- Seek opportunities to publish in higher-impact journals in partnership with others.

**Programme 39: Water Resources (WRS)**

Leaders research group:	Prof. Z. Su Prof. W. Verhoef
Research input 2013:	tenured staff: 3.0 fte total staff: 28.0 fte
Assessment scores:	Scientific quality 4 Productivity 4.5 Societal impact 4 Viability 4

*Scientific quality*

The group produces science at international levels of quality, as indicated by an above world average impact. It was noted that (i) the level of contribution was very variable across the group's members and (ii) the *h*-index score of the researchers was below ten with the leaders recording around twenty.

There is potential to publish in higher impact journals if undertaken in partnership with others.

The group indicated that they had a unique position in the domain of hydrological remote sensing with effectively no peers for comparison. This warrants further investigation.

The group had focused their efforts on advancing process understanding in Earth observation of land surface processes and their interactions with the atmosphere. The self-identified goal of the group was to create and transfer knowledge generated by remote sensing techniques to help support improved water management. The evidence presented to the reviewers supported clear and international level of strength in remote sensing along with a capability (rather than a similar high level of strength) in the actual 'transfer of knowledge to manage water' -- this despite attempts to respond to a similar comment in the 2010 review. The development of hydrological remote sensing expertise in developing countries (e.g., 'training the trainers') and the maintenance of long term monitoring sites were evidence of this well-established capability and were welcomed. The group are encouraged to further develop the transfer of knowledge gained with the aid of remote sensing to water management.

The group had a large and increasing number of PhD students, coupled to a research income that was also increasing, albeit less rapidly. A future challenge will be to decide what mix of funding to seek (i.e., exceptionally competitive national grant funding vs international project funding). The choice will influence future scientific quality and is dependent on the development of a long-term vision for the group.

*Productivity*

Productivity across a very wide range of research activities is at international and world-leading levels of excellence. Publication in refereed journals has increased markedly, as has the overall level of funding. The productivity on an FTE basis is impressive. Growth has been mainly through contract research and it is suspected that the numbers underestimate the proportion of funding from this source. This may have hampered the group's ability to develop a long-term vision and associated research strategy.

The key publications indicate the level of research leadership with many first-author papers. The majority of the publications are in remote sensing or allied journals and there is an opportunity for more joint publishing in higher impact discipline specific or major science journals.

Considerable attention was given to the mismatch between the impressive number (30) of PhD students and the graduation rate of 2-3 per year. Three of the issues were generic to ITC (1) a time-lag lag between a recent increase in PhD numbers and graduation, (2) the challenge facing sandwich students from developing countries and (3) variable student quality. These issues are well understood and are, we understand, being addressed.

WRS added a fourth issue, the requirement for each student to have *published* between three and five ISI journal articles prior to submission, on the grounds that this was the minimum standard required to produce an 'independent researcher'. The University of Twente require 'an extensive amount of work, which deserves to be published in national and or international literature'. Other groups within ITC aspire for each student to have three ISI journal articles in press or published and in practice, one such paper may suffice.

A different submission standard for the same degree represents a potential risk for the University as it leaves ITC and thereby the University open to student complaint. Moreover, the unduly high level of publication required in the WRS research group would appear to be a significant barrier to timely thesis submission.

There was also discussion of the self-evaluation of joint projects, open source software, modelling tools and joint projects discussed within section 8; however, these did not directly articulate the social benefits of the work.

#### *Societal relevance*

The group gains its strongest social impact through the training of scientists from the developing world and the role that these professionals play in their home countries once graduated. Given the fact that many of the ITC students are mid-career professionals or academics with PhD study sites in their home countries and that the vast majority return to their home country, this impact is very high. This in turn helps to support the Dutch international development assistance agenda.

There is good number of popular articles, but it is not clear where these are published. Despite an earnest attempt to respond to a prior review recommendation that the work be placed more soundly into the climate sciences, there was little action otherwise toward ensuring the societal relevancy of the many technical capabilities of the team. For example, the group's leadership in aspects of large international initiatives such as TIGER and DRAGON are beneficial and relevant and the support of GEONETCAST facilities at institutions in developing countries is very useful for the supply of remotely sensing data. However, these products and the benefits they provide appeared to the reviewers to be disconnected from the research activities of the group. Further information provided by the group confirmed that there were connections between services and research activity. However, more thought needs to be given to maximising the benefit of the link between these services and research. At a minimum, some partnering should be considered.

#### *Vitality and feasibility (viability)*

While there was some consideration of previous review and tactical placement for the future, including good opportunities for progression of junior staff in team, the review team were surprised to find that here was no vision or strategic plan for the future of the group. The WRS group's response to the prior review (to better link to climate science) was clearly successful (e.g., EU FP7 CORE-CLIMAX), however, the group did not take from that critique the broader message that they needed to better self-define additional strategies for research viability. The link to the GEO-10 plan, while praiseworthy, was an apparent earlier response to the SWOT, and this strategy does carry some risk, given the challenge of any highly contested funding round. The team also found the SWOT responses by the group tactical in nature (e.g., installing ground instrumentation, solving computing storage issues, cloud computing) when compared to the more strategic responses from the earlier external survey (e.g., improve social relevance, balance national and international agenda, involve itself with global-scale water issues). The group have done well to create a vital research environment but now is the time to think more strategically.

A strategic vulnerability is the high degree to which the group's longer term research ambitions are dependent upon contract work. Such research is opportunistic and *ad hoc*, plausibly interfering with the formulation of the team's vision. (However, we note that some of these projects have 5-10 year funding time frames, which do provide longevity to the research and should be strategically targeted). The focus on contract work represents in the view of the reviewers, a potential handicap to the development of world-leading science and may interfere with otherwise good opportunities to leverage the groups base funding.

#### *Recommendations*

- Develop a strategic plan around a common vision: to become within, say, five years the leading research group in Europe, in a well-defined area that falls within the group's current domain. Define the steps that will be needed to achieve that vision, through recruitment of students and academic staff, development of research infrastructure, and development of links with complementary and similarly ambitious groups.
- Develop a plan to move the standard for PhD submission to the norm for ITC.
- Seek opportunities to publish in higher impact journals in partnership with others.