

EXECUTIVE SUMMARY AND RECOMMENDATIONS

The overall objective of the evaluation of the ‘Greenland Ecosystem Monitoring Strategy and Working Programme 2011-2015’ is to assess the scientific, economic and organisational effectiveness of GEM and its scientific and societal impact. This evaluation is timely, since it occurs shortly before a planned synthesis and the development of a ‘GEM Strategy and Working Programme 2016-2020’ – a contribution to the continuing ‘Kingdom of Denmark Strategy for the Arctic 2011-2020’.

The review process involved the Panel members in a briefing in Copenhagen (March 2014) to familiarise them with the GEM programme and structure; a 12-day visit to Greenland (July 2014) to see the field operations (Bio-, Climate-, Geo-, Glacio-, and MarineBasis sub-programmes) and meet researchers at Zackenberg, Daneborg, Kobbefjord, Nuuk and Arktisk Station; a series of teleconferences (August-September 2014) with the Principal Investigators of the five Basis sub-programmes, the previous and the new GEM scientific leaders, and the chair of the GEM Steering Committee.

The evaluation was concluded with the presentation of a draft report at a participatory workshop involving 30 scientists and representatives of government institutions, including funding agencies, in Copenhagen on September 8, 2014. This helped facilitate an open, constructive discussion, including an analysis of strengths, weaknesses, opportunities and threats (SWOT) of the current work and ways to achieve a better integrated, and more holistic, work plan.

Much of the feedback from participants at the September workshop and their subsequent written comments, as well as further interviews, stressed that the GEM ‘Working Programme’ was evolving and should be viewed as “work in progress”. While this may be true, it was not the impression the Panel gained, either in the field or from the teleconferences with the Basis PIs. Rather than the Work Plan tactically supporting the current innovative GEM Strategy, the approach seemed to be to largely continue the monitoring at Zackenberg, with its extensions to Kobbefjord and, in some cases, Arktisk Station too.

Unfortunately, the structure of both the websites and the annual reports around the research sites reinforces this view of being ‘stuck-in-the-past’, rather than having a clear focus on the five thematic areas of the ‘GEM Strategy and Working Plan 2011-2015’. The key recommendations and additional suggestions of the Panel have been developed with the intention that the “whole (ecosystem programme) is more than the sum of its parts” (*i.e.*, Basis sub-programmes and research platforms). The Panel’s intention is to help enhance the long-term research excellence, as well as increase the policy relevance and strategic impact of GEM.

Overview: Although the collective GEM activities are able to address only some of the pressing issues of climate change in a general way, at relatively few selected localities and using specific techniques, the Panel supports the overall strategic goals of the GEM programme. When compared with other Arctic monitoring programmes, the Panel considers the activities of GEM to be one of the most comprehensive schemes, with the scientific contributions demonstrably important at all scales, from the local to the global level.

RECOMMENDATION 1: The Panel views the GEM activities as producing much excellent science, published in leading international journals, and, as far as we can judge, comparatively good ‘value-for-money’. In order that GEM can deliver its ambitious threefold mission, the Panel recommends it should be resourced for many decades to come. However, thought should be given to the GEM organisational structure, science focus and how the Work Plan maps onto the Strategic Plan to enable the programme to fully deliver its current objectives. Also, thought should be given to enhancing GEM’s flexibility to meet future science policy needs.

Policy Relevance: The Panel is of the view that GEM activities make a very significant contribution to the knowledge base on Arctic ecosystems, thereby meeting a central objective in the ‘Kingdom of Denmark Strategy for the Arctic 2011-2020’, namely “*The Kingdom will pursue a vigorous and ambitious knowledge building on climate change in the Arctic, and its consequences, in order to foster global and local adaptation to far-reaching change.*”

RECOMMENDATION 2: The Panel recommends that GEM builds upon the upscaling workshop held in November 2013 and prioritises efforts in ecosystem modelling, in order to both achieve a meaningful regional synthesis, and contribute more fully to the Kingdom’s policy objective.

The Panel notes that the Preface to the Kingdom’s Strategy for the Arctic 2011-2020 states that “It is our common objective that the Arctic and its current potential must be developed to promote sustainable growth and social sustainability.” and, elsewhere, states that “development must take place firstly to the benefit of the inhabitants of the Arctic and go hand in hand in safeguarding the Arctic’s environment”. If GEM were to rise to the challenges of the science underpinning these sustainable development aspirations, it would need to reconsider i) if its network of research platforms (sites) is fit-for-purpose, and ii) refining its focus on enhancing our understanding of Arctic ecosystem function and responses to climate change towards the outcomes for human well-being.

RECOMMENDATION 3: The Panel recommends that, given the Government of Greenland / Kingdom of Denmark’s expectations that the current monitoring and research do underpin sustainable development, GEM should explore the opportunity of establishing a GEM site in South Greenland, where climate warming is permitting agriculture to diversify its crops, increase local production and expand northwards. Without this information predictive models of the impact of ecosystem change farther north are likely to be of less policy relevance.

RECOMMENDATION 4: The Panel recommends, that GEM review the opportunity to increase its policy relevance by monitoring how climate change, and its interaction with other drivers, impacts ecosystem functioning and, thereby, influences the resilience of natural capital assets, the delivery of ecosystem services and, through wider collaboration, the consequences for human well-being.

Strategic Impact: The results of GEM activities have featured prominently in a number of major syntheses in recent years, including the ‘Snow, Water, Ice and Permafrost in the Arctic (SWIPA): Climate Change and the Cryosphere’ (AMAP, 2011) and the ‘Arctic Biodiversity Assessment’ (CAFF, 2013). These publications reflect that the monitoring sites, especially Zackenberg, are well embedded in circum-Arctic networks. The added value of these international collaborations leads to ground-breaking research which is published in the highest impact journals, reinforcing the spirit of wider cooperation.

RECOMMENDATION 5: In order to maximize the impact of the planned synthesis in 2015/2016 of the GEM research, the Panel recommends that the synthesis focus primarily on cutting-edge, interdisciplinary research to address the mechanisms driving change in the structure and function of Arctic ecosystems, rather than what was done in each Basis sub-programme, or at a particular site. To do this will also require a major effort in synthesis of the existing data, subject to the database being complete, and rectifying the generally slow progress on upscaling models.

Science: The Panel observed a mixed effectiveness with regard to building a symbiosis between the long-term Basic/Basis measurements and the process-focused research studies, some of which are short-term. To some degree this varied between sites and the length of time the monitoring had been established.

RECOMMENDATION 6: The Panel recommends a deliberate effort to better integrate collaborative projects into the long-term observational monitoring, so that the new knowledge becomes a direct influence on planning of the continued long-term measurements. The Panel suggests that this could be achieved by a review of the current 13 questions (see RECOMMENDATION 7) and a more systematic implementation of the adaptive monitoring concept (see RECOMMENDATION 8). This approach may involve the active encouragement of projects at Kobbefjord, and elsewhere.

Although large portions of the GEM research effort are doing outstanding work within the five themes, the Panel considered many of the 13 questions too general to evaluate progress in answering them meaningfully. A weakness of such general questions is that almost any study can be argued to be working towards answering an element of the question, without necessarily making the programme effective in producing novel insights that can be linked easily with other sub-projects, apparently focused on the same question.

RECOMMENDATION 7: The Panel recommends that there needs to be more strategic thoughts about a SMART¹ set of the over-arching questions. The refinement of the central questions needs to be an on-going process and integral to the implementation of the GEM strategy through the concept of adaptive monitoring (see RECOMMENDATION 8).

¹ Here SMART is Specific, Measurable, Achievable, Realistic (though some suggest “Results-focused”) and Time-bound.

The Panel was concerned that the number of measurements across the Basis sub-programmes has expanded to more than 3,500 and was of the view that there needed to be more focus on the (revised) questions, as well as on the consistent and iterative use of the adaptive monitoring concepts, in order to hone the monitoring regimes, both within and between the Basis sub-programmes and across the sites.

RECOMMENDATION 8: The Panel recommends that the adaptive monitoring approach is implemented more systematically and involves, where possible, the field staff responsible for the on-going data collection, several of whom told us they didn't feel connected to the outcomes.

With the exception of the glacial outbursts at Zackenberg, the Panel found little indication of progress in identifying potential threshold effects in either the terrestrial or marine ecosystems. In general where data series have been inspected, many relationships are linear within the range of variation in temperature and precipitation witnessed to date. One alternative approach would be to build process-based models and explore responses to sustained extremes – shifts in mean of explanatory variables.

RECOMMENDATION 9: The Panel recommends that GEM explores the scope for more specific experiments, as well as expending more effort on process modelling, in order to investigate the likelihood of thresholds in Arctic ecosystems and exploring their potential consequences.

The Panel is concerned that delays in delivering several of the Strategic Initiative projects has had the effect of retarding progress in developing the upscaling, modelling and prediction thematic area. In general, the Panel wishes to encourage more process understanding of internally consistent frameworks (*e.g.*, numeric models) in order to calculate future states based on a quantitative mechanistic understanding, this is particularly crucial for the approach of upscaling from local specific sites to regional scales.

RECOMMENDATION 10: The Panel recommends that GEM develops a collaborative (institutional) modelling and prediction 'group' where there is continuous interaction of fundamental thinking and curiosity to interrogate the incoming data, enhancing understanding and refining approaches to both the ongoing monitoring and research.

The Organisation: The 'coalition-of-the-willing' approach, both among the institutional supporters of Arctic ecosystem science and the passionate researchers themselves, means that GEM activities have achieved a tremendous amount in terms of improving our understanding of species biology, important elements of ecosystem function, and of their physical surroundings. However, the Panel concluded that to date there is little evidence of the more novel aspirations of the 'GEM Strategy and Working Programme 2011-2015' – a more holistic understanding of interacting terrestrial, limnic and marine eco-systems in Greenland, and the wider Arctic – being delivered by the current structure of a Steering Committee and a Coordination Group.

Although the Panel is very encouraged by the re-cent appointment of a new scientific leader, our view is that he and his team will need dedicated support. Whether this

support can be achieved without the current partner-ship of institutions creating a dedicated GEM Centre, including a stronger presence in Greenland, is a debatable point?

RECOMMENDATION 11: The Panel recommends that, as soon as possible, GEM establishes an independent (of the ministries and other stakeholders), international advisory board to provide the high-level overview and support to both the Science Leader and the stakeholders.

In terms of logistics, the Panel was of the view that all GEM research platforms should be more energy efficient and critical of current waste management practices. Neither the Danish Energy Agency nor the Danish Environmental Protection Agency should be in a position where their sponsored initiatives could be criticised for lack of ‘best’ practice.

RECOMMENDATION 12: The Panel recommends that there is an options review and feasibility assessment of green energy generation and utilisation efficiency, as well as dealing with all forms of human waste management, at all sites.

The Panel believed that the annual reporting structure by site (research platform) was no longer fit for the purpose, and impeded measuring the progress of GEM. Some of the Basis sub-programmes merely reported what was done year after year, just changing the dates between years. Often there was a lack of description of what was found, and, even where more specific results were described, there was little or no interpretation. Given that little of the specific GEM work, undertaken since 2011, has been published yet, the historical format of the reports made the job of the evaluation Panel considerably more difficult.

RECOMMENDATION 13: The Panel recommends the development of a ‘corporate’ GEM-brand, facilitated through a single GEM annual report and a unified website. Both the GEM annual report and the website should be structured by the five themes of GEM, disaggregated to the level of the re-evaluated set of the 13 questions. Also, the monitoring and the relevant science projects should be integrated accordingly under the relevant theme/question.

The Future – GEM 2.0: In addition to encouraging GEM to implement the previous 13 Recommendations over the next five years, the Panel identified two other areas to enhance the strategic impact of GEM: i) Join terrestrial and marine ecosystem studies together through a major effort in interdisciplinary process-modelling; ii) Consider how GEM fits within the wider effort to deliver Arctic research in the Kingdom of Denmark.

First, the Panel encourages GEM to focus increasingly on understanding the causes and consequences of ecosystem change and generate the capacity to predict, through mechanistic models, the outcome of future scenarios of environmental change at local, regional and global scales. To do so requires confidence about the representativeness of the sites at which measurements are conducted, and their appropriateness for upscaling to regional scales (see RECOMMENDATION 3). Further, since the regional importance of Greenland is due to its ice-dominated land mass surrounded by productive seas, more emphasis needs to be placed on the interaction of terrestrial and marine processes.

RECOMMENDATION 14: The Panel recommends a much stronger explicit link between the coastal marine work and the terrestrial/limnic research, through a stronger strand/theme of integrated conceptual thinking, observation and process models.

Second, the Panel was concerned about the fragmented approach to Arctic research in the Kingdom of Denmark, with interests and responsibilities widely distributed across many ministries and research institutions. Although, the ‘Terms of Reference’ questions are specific and only consider how GEM should be organised in the coming years and decades, we encourage the wider-than-GEM stakeholder community to think about a more joined-up approach to achieve greater added value and efficiencies.

Since our first meeting in Copenhagen in March, throughout our visit to Greenland in July, and in the weeks since returning, the Panel has spent a considerable amount of time pondering the important broader issue of how research in the Arctic is organised in the Kingdom of Denmark. The three Panel members all come from countries with dedicated polar research institutes (combining science and logistics), as well as nations with considerable strengths in polar research within the university sector. These nations maintain these institutions partly because many environmental changes are dramatic, fast in real time, with global effects, but also partly for political reasons, because these changes influence the well-being of their own societies. Given the geopolitical importance of the Arctic to the Kingdom of Denmark, it is unusual in not having a dedicated institution to ensure that its strategic needs are integrated across the science-policy interface. As indicated above the Panel believes that, at the very least, there is a need for greater co-operation between the universities and other relevant research institutes, as well as a cohesive partnership among the funders, including the different ministries with a stake in the Arctic, to achieve a virtual centre, at the very least.

RECOMMENDATION 15: The Panel recommends a wider review of the potential institutional structures to meet the Kingdom of Denmark’s future needs for high-profile excellent and relevant research in the Arctic, recognising the considerable financial and political implications. Although it is not within the remit of the Panel’s mandate to define specific proposals, one of several possible models is a ‘centre’ with two ‘hubs’. One ‘hub’ would involve growing the capacity to implement the integrated monitoring, research and logistics from a base in Greenland. The other ‘hub’ involves creating a dedicated process modelling group which can draw on the expertise of Danish research institutes and universities in Denmark and more widely (see RECOMMENDATION 10). This second ‘hub’ would co-locate the relevant researchers in a single site. The two hubs can be linked by the two original GEM concepts: i) a holistic study of the Greenland ecosystem, but expanded to include other drivers in addition to climate change, and ii) the principles of adaptive monitoring, which integrates both science questions, data collection, analytical approaches (incl. modelling) and interpretation in an iterative way, as mentioned previously.