

Proposal for a national research programme:

## Coping with Climate Change – Land Use in the Area of Tension of Resource Conservation, Food and Energy

put forward by the German National Committee on Global Change Research (NKGCF) at its 44<sup>th</sup> meeting on 28<sup>th</sup> April 2008.

The German National Committee on Global Change Research proposes the immediate establishment of a substantial national research programme on “Coping with Global Change – Land Use in the Area of Tension of Resource Conservation, Food and Energy”.

The programme sets out to combine existing capacities in this area at universities and other research organisations as well as bringing together basic and applied research. The programme aims at developing strategies for the targeted management of land use in order to prevent the causes of climate change as well as finding ways to adapt to its inevitable results. The proposal is addressed at the national research funding institutions DFG and BMBF.

This recommendation is based on the following: the NKGCF’s proposal to establish a national research initiative on climate change (30<sup>th</sup> March 2007), the expanded proposals for establishing a national research programme (25<sup>th</sup> May 2007, 17<sup>th</sup> January 2008), the general discussion of the proposal with the DFG’s Senate Commissions for Joint Geoscience Research, Agricultural Sciences and Water Research as well as the results of discussions with representatives from the relevant scientific disciplines at the national colloquium on this topic organised by the NKGCF on the 3<sup>rd</sup> and 4<sup>th</sup> April 2008 in Bad Honnef, Germany.

### 1. GOALS OF THE NATIONAL RESEARCH PROGRAMME

The use of the planet’s limited land surface area is divided between the conflicting usage priorities of food production, energy supply, urban living space and the ecosystem service sector (Figure 1).

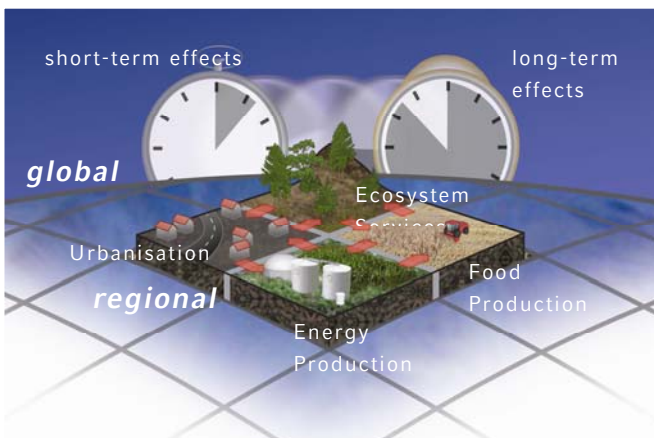


Fig.1: Land use in the area of tension of food production, energy supply (renewable energy), and resource conservation, urban living space and the ecosystem service sector (ESS) in spatial and temporal dependency.

Global climate change will lead to regional changes in the natural conditions on which land use decisions are based. These changes will be in addition to the already existing

close interrelation of global factors (seen in the globalisation of economic activities and market integration through global trade) and regional factors (such as the availability of land, human and natural resources and demographic development).

Decisions on land use on the regional level, where such decisions are generally made, have to be based on both long-term and short-term considerations. Regional decisions on land use are, however, also strongly influenced by global factors such as climate change and global trade affecting in turn both climate change and social and economic development.

	Regional	global
Short term	Food Urban living spaces ↔ Land ↔ ESS Energy supply	Food Urban living spaces ↔ Land ↔ ESS Energy supply
Long term	Food Urban living spaces ↔ Land ↔ ESS Energy supply	Food Urban living spaces ↔ Land ↔ ESS Energy supply

Fig. 2: Aspects of land use between the conflicting areas of food production, energy supply, urban living space and the ecosystem service sector (ESS).

In Figure 2, the short-term perspective (over about 20 years) outlines ways in which the challenges presented by EU resolutions on climate policy 20-20-20-10 goals can best be achieved. Research will take into account both short- and long-term perspectives (50 to 100 years), concentrating on more fundamental, normative questions such as best possible use of land for the attainment of certain sustainability goals in selected regions.

The research programme proposed by the NKGCF is aimed at the development and validation of strategies on handling climate change particularly in terms of the targeted management of land use and the processes on the Earth’s solid surface associated with land use (substance and energy flow and ecosystem services arising from the animate and inanimate environment). Global and regional aspects will be examined from a short-term as well as a long-term perspective. Integrative approaches that involve all relevant scientific disciplines as well as the people concerned and affected will be created, further developed and put into practice in a relevant way. The essential issues to be raised in this applied basic research are aimed at an enhanced understanding of (i) natural and social processes and the (ii) interplay of land cover and land use based on integrative research.

The purpose of applied research and development is the identification and systematic examination of courses of action (social, technological, economic and ecological), which are based on the application of insights gained for the development of targeted sustainable land use. It is expected that such courses of action will identify effective and efficient prevention of the causes of climate change and the adaptation to its inevitable effects for the different regional conditions in the areas under investigation.

## 2. NATIONAL RESEARCH PROGRAMME PARAMETERS

Land surface area represents one third of the Earth's total surface. It plays a central role in all important energy and material cycles within the Earth System. Biotic and abiotic processes and natural material cycles on the land surface contribute enormously to the stability of the Earth System as well as to the sustainment of the basis of life on Earth. Furthermore, the land surface is the primary living and acting space. Until now, humans have primarily obtained their main requirements for life in the form of food, natural resources and raw materials from the land surface. Land surface is an essential basis for food production and water supply and in addition functions as a settlement and circulation space as well as being used for waste disposal.

In the last 300 years, mainly in the 20th century, humans have used the largest available land surface space for food and energy production and as a settlement area. Today, the changes in land use mainly occur as a result of decentralised, generally microeconomically determined decisions taken by a multitude of actors. The expansion of agricultural areas and desertification is pushing back natural ecosystems all over the world. In turn, the expansion of settlement areas occurs largely at the expense of agricultural areas. The decisive factors in this restructuring have thus far been the growing population, industrialisation and the resultant changes in lifestyle and consumer habits.

In the course of the aforementioned land use, humans have come to dominate dynamic, important material cycles of the Earth System such as water, carbon, nitrogen, and phosphorous cycles in order to increase productivity. The global water and carbon cycles are already more than 50% controlled by human action, the nitrogen cycle 80% and the phosphorous cycle more than 95% controlled. Food produced with the aid of these cycles is part of a strong growth in international trade which, among other things, leads to a rapid growth in population density even in regions with limited land use capacity such as arid regions. Agricultural plant products are increasingly used as renewable energy sources and animal feed in the highly developed regions of Europe, the latter in order to satisfy the high demand for animal products. For example, Germany requires twice its total landmass to satisfy domestic demand for plant products and animal feed, amongst other things. In order to satisfy current dietary requirements and habits, animal feed is imported on a large scale. The strain on land resources as well as the consumption of natural resources of exporting countries (i.e. the potential damage to the ecosystem associated with their production) is not reflected in the price of trade goods. Land surface processes such as the production of food and animal feed as well as energy including water purification, stabilisation of life through biological diversity and the regulation of global and regional climate are thus contained on a non-renewable land surface which is increasingly competing with the space needed by humans.

The globalisation of the world's economy has accelerated the changes in land use and intensified the use of natural resources. World markets have made this transparent and have accentuated the increasing scarcity of natural resources through a rise in prices for raw materials and food. The interrelation between global (world markets and global trade) and regional factors (availability of land surface, natural resources and demographic development) has become increasingly important in the course of globalisation. A substantiated concept regarding how the effectively non-increasable land surface can continue to sustainably provide natural resources and ecosystem services for a continually growing population with increasing income and resource-intensive lifestyles is still lacking.

The scarcity of natural resources brought about by population and economic growth is further intensified by anthropogenically caused climate change which will affect the utilisation potential of the land surface on a regional level at the same time as demanding adaptation processes and emission prevention measures. These in turn make increasing demands on the land surface. As already seen from the factors influencing land use changes, the global-regional interrelation also plays an important part in this area. The mass transfer between atmosphere and land surface is a highly complex process within which the land surface can function as source or sink. Incipient climate change is caused in great part by the reorganisation of land surface and the greenhouse gases emitted in the process.

Besides the changes in carbon sources and sinks through land use, the hydrosphere is especially affected. Changes in evaporation, overuse and pollution have devastating effects on the water cycle, endangering its viability. Biodiversity is primarily endangered through land use. It is therefore certain that the effects of climate change noticeable today, together with the growing population and the worldwide rise in demand for resources, will lead to further strain on global land resources. This will become especially apparent in the developing regions of the Earth.

The regional differences in the intensity of land use and the efficiency of use of natural resources are huge. For example, the quantity of rainwater used for the production of one kilogramme of wheat flour in Italy is three times as much as that used in the Netherlands. The amount of rainwater used to produce one kilogramme of beef in Mexico is three times as much as that used in Japan. These differences would make it appear that there is huge potential to increase the efficiency of use of natural resources. However, in comparison to the intensive use of space by emerging countries in East and South Asia such as China and India as well as European and North American countries in which nearly all suitable land is used intensively, there are still regions today in which the human impact remains small. These include the large permafrost regions in Asia and North America as well as desert regions, parts of the Amazon and Congo basins and parts of sub-Saharan Africa. In these areas, intensity of use is primarily determined by the availability of natural resources and by population density.

The global rise in temperature will change the regional distribution of use potential on the land surface that has until now been taken for granted. Available climate scenarios thus predict that in regions with low precipitation

rates, precipitation will decrease further while in regions with high precipitation rates, precipitation will remain the same or even rise. The rise in temperature will also provide potential land use areas that have thus far been of limited use to humans such as boreal coniferous forest regions and permafrost regions. In other regions, on the other hand, such as the Mediterranean region, the utilisation potential will decrease.

As a result of expected population growth, predicting another 3 billion people by the year 2050, additional living and circulation areas totalling 120 million hectares are foreseen (assuming 0.025 hectare per person). This settlement area is approximately equal to twice the agricultural land used in the EU today. A similar estimate predicts that the increase in the number of cars by 2050 will require an additional 60 million hectares in storage and road space. Based on these estimates, in addition to the thus far effective means to increase yields, the extension of worldwide cultivation areas in order to increase food production and to initiate the production of renewable energy sources must be examined critically for its potential.

In addition to all the issues presented thus far regarding the region-specific use adaptation of the natural resources of the land surface to climate change and societal developments, the goal of sustainability must not be neglected. Currently, sustainability is not yet an urgent goal of land use decisions. The results of the Millennium Ecosystem Assessment 2000 clearly show that sustainability is a basic requirement for securing the functionality of the life support system on Earth and the Earth System ecosystem services that are essential for the Earth's human population. In order to reach the goal of sustainability when faced with land resource scarcity and climate change as depicted thus far, future land utilisation must be understood as goal-oriented change of land surface processes.

The development in the political debate on the necessary adaptation of the energy system towards sustainable energy supply has given new meaning to the options provided by the land surface. The political specifications laid out by the EU regarding the increased use of biogenetic energy sources within the Renewable Energy Road Map resolved last year, together with an increase in food demand has provoked an intense discussion concerning the extent to which it is possible to use renewable raw materials for the supply of energy. The potential emission reduction associated with this is in opposition to the competition for space between energy and food crops as well as the question of sustainability of modes of production (palm oil, soya or sugar cane). From a regional as well as from a global point of view, the current standard of knowledge does not enable definite propositions to be made on how the political specifications can be reached efficiently and effectively. This results in important research questions for the proposed national research programme that must be appropriately combined with long-term timescales.

The identification of adaptive measures for climate change through targeted land use design thus leads to a mass of different criteria. It is necessary to

→ Take interactions between different regions affected by global processes into consideration.

Through their influence on atmospheric and hydrological circulation systems, changes in land

use in one region can affect use potential in other regions of the Earth by causing changes in precipitation and temperature. For proactive land use planning in a global context, these interactions must be understood and their intensity estimated. This facilitates the examination of differences in the sensitivity of the Earth System to regional land use changes and to the identification of regions in which changes in land use have a particularly big impact on the Earth System. Furthermore, this allows for quantification of the effects of regional decisions on global climate systems in a wider context. However, changes in land use are increasingly determined by the interconnected international trade of agricultural products. In the course of this trade, natural resources such as land, rainwater used, estimated energy and other natural resources (e.g. aquifer and river pollution) in the exporting country are drawn on and thus made unavailable for domestic use. In return, the import of food in the importing country reduces the use of land and natural resources. International trade in agricultural products thus influences land use worldwide and must be incorporated into the global consideration. A comparative analysis of the efficient management of land resources and related natural resources (e.g. water, energy, soil, biodiversity) in different regions can therefore lead to considerable reductions in the use of natural resources. The current standard of knowledge regarding these global mechanisms of resource use and land use changes is still rudimentary. Current knowledge is not even able to provide data on the relative influence of changing international trade and changing global circulation on the global distribution of land use.

and

→ Take into account regional use potential and limitations, economic, ecological, societal, institutional and technological conditions and particularities.

It can additionally be assumed that in the future, decisions regarding land surface management will be made mainly on a regional level. Thus limited land resources entail the significant consideration of the effects of different use alternatives as well as the efficiency of using available natural resources for the discovery of solutions to conflicts of use.

→ Consider the course of climate changes on a regional level.

This leads to a time-dependent change of use potential, whereby the different timescales that are related to different use options (e.g. forest vs. settlement vs. agriculture) must be taken into account.

and

→ Consider climate change, population development, economic development, and the retention of ecological, economic and social sustainability as the development goal.

Thus regional decisions on land use are caught between the poles of food production, energy supply, urban living spaces and ecosystem services. In this context, the decision not to use land is also considered to be a decision on land use. A relatively constructive resolution of this conflict must be

based on a detailed analysis of the trade-offs between the different land use alternatives that are available in a given region. The knowledge gap in this area concerning the process as well as the integrative, interdisciplinary method must be closed. While research into only one of the factors addressed may certainly close important sectoral research gaps, the proposed national research programme does not incorporate these because of the integrative character of the issue at stake. The aim is rather to identify optimised solutions in future land use within the conflict situation surrounding the factors described.

Basic, contextual and practical knowledge concerning global and regional analysis of land surface potential is a prerequisite for the targeted planning of land use. Knowledge gaps exist (i) in the methodical area of integrative, interdisciplinary use analyses, (ii) in the process involving factors and decision mechanisms, how land use is and should be planned, and how this affects the functioning of the ecosystems involved, as well as (iii) concerning how and how effectively processes on the Earth surface can be designed so that they contribute sustainably to the desired adaptation and prevention goals. As Figure 2 shows, these issues, both from a short-term as well as a long-term perspective are present largely on a regional level where decisions on land use are made. The short-term perspective mainly concerns research clusters from all areas of German research in order to focus on such areas as how to best fulfil the EU's political objectives of reducing greenhouse gases by enhancing bioenergy. The long-term perspective also concerns a joint and equally important research effort by all German research pillars in order to investigate more basic, normative questions (e.g. the best possible future land use for attaining certain sustainability goals) in selected regions. Development over the next 15 years will have a significant influence on other future long-term developments and, as the Stern magazine's report has shown, determine which economic gains must be allocated to the adaptation to climate change and the appropriate prevention strategies relating to climate change in the medium term. In this respect there are close interactions between the regional knowledge acquired on the short-term and the long-term timescale. These interactions will be considered in the respective research approaches.

The quality of research findings on a regional level will, due to the global dimensions of climate change and international trade, on a short- as well as long-term timescale be decisively determined by the degree to which the regions under examination are integrated into the global context. These global influences cannot be predicted with any precision. They must therefore be incorporated, jointly developed and applied in regional research as future scenarios that comprise additional foreseeable developments (population, economic development, processes of globalisation in international politics and economic, international trade, etc.).

However in order to achieve this, the level of regional detail in global future scenarios must be enhanced significantly in relation to the detail that is available today. Only then will it be possible to draw reliable conclusions on the effectiveness of targeted land use plans on a regional and global level.

Thus in order to identify courses of action for adaptation to climate change through planned land use within a national research programme, regional and global as well as short-term and long-term perspectives must be considered concurrently.

Applied research on future land use planning will lead to certain courses of action. The timely and serious dialogue

between researchers and regionally and globally affected parties will have a huge effect on the results of applied research into the organisation of land use. On the other hand, the development of research questions and realistic assumptions of future scenarios requires constant dialogue between research, stakeholders and decision-makers. These aspects are therefore an indispensable and central part of the proposed national research programme.

### 3. STRUCTURE OF THE NATIONAL RESEARCH PROGRAMME

Figures 1 and 2 present a structure and approach to the proposed national research programme which are depicted together in the diagram in Figure 3.

The proposed research programme will comprise components designed to handle regional as well as global aspects of superordinate research issues in a reciprocal manner. The management of global and regional components requires extensive methodological developments to describe the different processes, cycles, natural resources, trade flows as well as the conflicts of land use between the different ecosystem services, food production, energy supply, and urbanisation and their reciprocal relationship and to make all this predictable. All regional studies should apply the same set of globally consistent future scenarios.

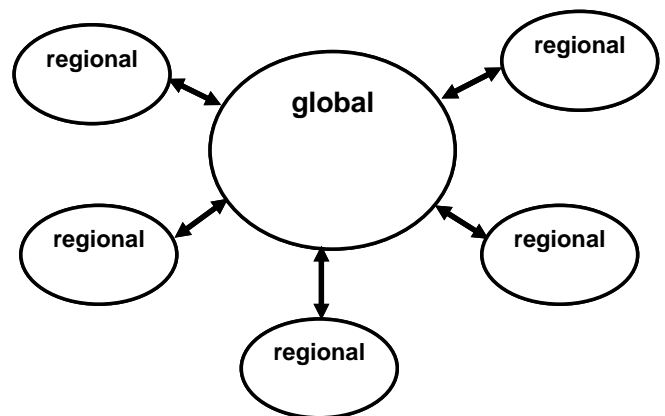


Fig. 3: Diagram of the superordinate structure of the national research programme "Coping with Climate Change".

The regional components of the research programme thus primarily address:

- Conflicts regarding use, mechanisms of action, consideration of global conditions
- Examination of the effects of future scenarios in short and long termed scales
- Development of courses of action (in terms of political decisions) as well as an examination of their effectiveness and effects

At the same time, the interaction between regions and global process sequences should be examined and future scenarios deduced. The following aspects are to be incorporated into research particularly on a global level:

- Land conflict between food production, energy supply, urbanisation, ecosystem services on a global level
- Identification of the conditions of climate change
- Identification of regional hotspots resulting from climate change, involving regional actors
- Development of future scenarios in short and long termed scales

The preceding analysis of the changes in the demands that the further development of society as well as climate change will make on the Earth leads to a number of comprehensive research questions. Among these are:

- What determines the current use of land surface area in food production, the energy sector, human settlement, and ecosystem services on a regional and global scale?
- Which regional and global drivers determine land use?
- What possibilities concerning the targeted development of land use exist or must be established?
- What is the relation of the current use capacity of land resources to its actual use on a regional and global level? What is the potential for changes or extensions of use?
- How will use capacity of the land surface change in these four areas in the course of global changes (climate change, population development, environmental pollution, technological development, plant breeding, ...)?
- What are the current and future conflicts in the four areas? What are the trade-offs and how will these change with global changes in future?
- What is the ideal global and regional use of the land surface area?

How do changes in land use affect the climate system over material cycles (especially the greenhouse gas, water and energy balances)?

#### 4. MAJOR FOCI OF THE NATIONAL RESEARCH PROGRAMME

Decisions regarding land use are generally made on a regional level. The proposed national research programme mainly seeks to explore regional strategies for the adaptation to climate change and simultaneously exploit possibilities for emission prevention offered by targeted land use management. The exploration of strategies must therefore take place in regionally confined hotspots of global change. Thus the proposed national research programme will concentrate on case studies from the world's regional global change hotspots. There are two levels to the national research programme:

##### 4.1 Global level

This focuses on the exploration of global processes and developments related to land use, predominantly in the areas of climate change and economic globalisation and also on the influence of regional level decisions on global processes and developments. One pillar of the proposed national research programme is thus a strongly global element, involving the integrative examination of global changes, for example in the field of climate change, social institutions, economic processes, nature and natural

resources. It identifies the drivers of global change, translates the processes into models and deduces future scenarios in climate, economic, trade and population developments as well as the efficiency of ecosystems. These future scenarios must be developed in close coordination with analyses of regional hotspots.

##### 4.2 Regional level

In future, targeted planning of land use will apply to nearly all regions on Earth. Not all regions are affected by climate change and other global changes to the same extent and in the same way; the urgency thus varies from region to region.

Germany and Europe have a huge potential for adapting to climate change through land use planning.

Dramatic changes of land use capacity generated by climate change are also expected in Europe. Furthermore, significant possibilities and decisive need for action are expected to arise in global change hotspots such as Africa, Asia or South America. While dramatic conflicts in land use already exist in these regions, these are expected to intensify in future. How climate change is handled in these regions is expected to affect Germany and Europe directly and indirectly. The research programme is therefore intended to be implemented in selected regions that are global hotspots of land use change.

Below are some **examples of regional hotspots**:

In *Central Europe (Northern Italy to Northern Germany)* climate change will change the basis of decisions on land use regionally in different ways, although all such changes will have a considerable effect. These differences arise from the shift of climatic zones. An expansion of dry regions and of Mediterranean climate towards the north is expected. This is associated with different ways to potentially manage agriculture and forestry (e.g. changes in crop rotation, possibly two harvests in some regions), changes in water availability and the introduction of new animal and plant species as well as the changes in biological variation and ecosystem services resulting from these activities.

These changes entail a sustainable development of water, substance (e.g. carbon) and energy cycles under multiple criteria of energy and food production, development of technologies, management of processes, decisions by actors, whilst taking into account the protection of resources and the ecological functioning of the entire system.

With concurrent dynamic economic development and the thus resultant strong environmental impact, climatic constraints on *highly dynamic growth regions* are expected to render a continuation of current land use practices impossible. These regions are also undergoing extreme urbanisation, intensifying the pressure on land use and massively influence intact ecosystem functions. This raises the question as to how the interaction of land use systems with economic growth, extreme urbanisation and climate change can be directed in a manner that combines earnings improvement with resource protection while also taking into consideration cultural, social and political aspects.

*Permafrost regions* are heading for drastic changes in land cover through increased warming, changes in precipitation and thawing soil. Due to destabilised permafrost soil, these regions could emit immense amounts of climate-relevant gases (carbon dioxide and methane) which would further

contribute to global change. At the same time, these regions could be potential future agricultural and forestry production areas and would thus serve to secure and increase food and energy production. That is why the decision of stakeholders of different areas (social, political, economical) are of great interest in terms of global perspective and need to be integrated. As 25% of the world's land surface is currently affected by permafrost, these regions give rise to the issue of the intensity of greenhouse gas sources or sinks, the effect of a shift in vegetation zones northward as well as future land use capacity.

*Dry regions and their peripheries* are especially relevant because resources in these areas are inherently exceptionally limited. They are especially sensitive to rises in temperature, a decline in precipitation and population dynamic. All this accelerates desertification. It can be assumed that these regions will fall below a critical productivity value in the absence of targeted plans. In order to alleviate crop failures caused by drought, migration problems of environmental refugees and the loss of usable living spaces as much as possible, new concepts of land use are urgently needed, particularly in regard to adaptation to climate change. Further research is also needed in the area of imminent changes in soil, biodiversity and water resources, the technical and conceptual optimisation of sustainable water use and food production, as well as options for energy production and settlement policy.

## 5. THE ROLE OF GERMAN RESEARCH FUNDING INSTITUTIONS AND RESEARCH INSTITUTIONS

The relevance and complex nature of the proposed research topic and the development of practical, optimised solutions justify a concentrated national research programme that brings together all the available competencies in Germany. An integrative, interdisciplinary approach is required along with the coordinated cooperation between basic research and applied research as well as the interaction with stakeholders.

Due to their specific profile, the German research funding organisations addressed by this research programme are able to support different aspects of the programme with the tools available to them. The following contributions are thus seen as feasible:

### 5.1 DFG (German Research Foundation)

The proposed research programme entails a great deal of basic and applied basic research into region-specific approaches and into the integration of natural and social science disciplines. The development and application of integrative regional predictive models and scenarios for the adaptation to climate change through planned land use is a key part of this programme. Some initial specific regional and discipline-based approaches to integrative modelling and scenario generation in some aspects of land use already exist. These could form the basis of more integrative research endeavours.

Germany can draw on a highly capable and solid basis of research groups in those natural and social science disciplines involved in the development of applicable integration approaches. The development of such

approaches can particularly rely on the broad range of university subjects available and further momentum comes from the existence of excellent non-university research groups. The NKGCF considers that the German Research Foundation is in an excellent position to participate in the development of the necessary basic knowledge in integrative methods and approaches on a regional level: The DFG is especially good at bringing together scattered potential and promoting young scientists.

### 5.2 BMBF (Federal Ministry of Education and Research)

New research methods and approaches will arise during the course of basic research in the area of integration. The application of such methods and approaches in integrated regional models facilitates a thus far unknown level of specificity and attention to detail in the development of courses of action for future land use planning in the main areas presented here. The aim of applied research therefore lies in the systematic identification of effective and efficient planning possibilities for land use in terms of mitigation of and adaptation to the consequences of climate change.

The extensive past experience of BMBF-funded research projects will aid the further development of practically oriented research. The close incorporation between all involved, including affected parties, in the national research programme will support the successful development of courses of action. Together with different stakeholders, different options for land use will be drafted for the aforementioned main areas. These will serve to develop different scenarios for future land use planning. They will then be tested for their effectiveness, efficiency and feasibility. The NKGCF thus suggests that the BMBF's contribution be focused on the practically oriented aspects of the national research programme in order to provide decision-makers with the necessary contextual and practical knowledge.

### 5.3 NON-UNIVERSITY RESEARCH ORGANISATIONS

The involvement of non-university research organisations offers outstanding potential for top researchers and research groups that are active in this area to be involved in the proposed programme. The proposed national research programme is only fully viable with the participation, use and valorisation of the excellent research infrastructure that exists in Germany. This includes among others the available computing capacity of the DKRZ (German Computing Centre in Hamburg) for the further development of global and regional climate predictions, the measurement facilities of terrestrial non-university research organisations such as the ZOTTO observatory in Siberia, the trace gas observatory ICOS and the TERENO network as well as the German remote sensing platforms HALO, TerraSAR and EnMAP. Further options include the extensive databases of past research programmes. The NKGCF considers the collaborative, complementary use and the provision of existing research infrastructure for university research groups as an original contribution by non-university research organisations in support of the national research programme. This contribution by the non-university research organisations could potentially form the nucleus of the programme since different groups in basic research and from practically oriented research can come together in a jointly used infrastructure and thus exchange findings from the emerging joint work groups.

## 6. STEPS TOWARD IMPLEMENTATION

Interdisciplinary integration and further development of knowledge relies on the fact that the whole range of scientific potential for those disciplines involved in Germany is addressed. In order to find a solution to the research questions addressed it was proposed that a competition be held to determine the best suggestions. The NKGCF suggests that all research funding organisations concerned publish calls for proposals for the research topics addressed. This ensures the effective organisation of the competition and enables the interested consortia to assemble in a topic- and problem-centred fashion. This also facilitates a quality-oriented selection of appropriate consortia prior to the filing of applications on the basis of the following calls. Successful international integration of the projects requires the effective use of the four international global change programme (IGBP, IHDP, WCRP, DIVERSITAS) platforms and in particular the Earth System Science Partnership (ESSP).

- Questions arising must focus mainly and not partially on urbanisation, energy supply, ecosystem services and food production.

The NKGCF suggests the following criteria and strategies for the implementation of the national research programme:

- The overall structure will be characterised by a group of global consortia and 4-5 regional consortia which is appropriate for the topic if the consideration of different regional hotspots is to be guaranteed.
- A 3-phase model would appear to be suitable for the realisation of the national programme.

In the first phase, the global basic principles and assumptions for a future scenario are to be jointly compiled and defined. In this phase, the global consortium will work closely together with the regional consortia. In parallel, the regional consortia will concentrate on the development and validation of appropriate integrative methodical approaches and the gathering of relevant data. At the end of the first phase, the jointly developed future scenario sets out the basic conditions for all further work by the regional consortia.

In the second phase, the implication of these conditions for the individual regions will be developed, and the interaction between global and regional research questions addressed in greater detail.

The third phase focuses on the drafting, validation and evaluation of results together with regional stakeholders.

- Successful consortia
  - must adhere to integrative research approaches. Sectoral research is to be determined from knowledge deficits in answering the superordinate research question.
  - must link university and non-university research. For this reason, they must show a well-balanced composition of university and large research institutions.
  - should contribute to a timely and substantial dialogue with stakeholders.
  - should guarantee the transfer of knowledge.
  - should particularly focus on the support of young scientists, in particular in the area of interdisciplinary integration.