Climate Change and Institutional Adaptation in transboundary river basins

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1) Introduction

The IPCC report from 2007 has made it very clear: climate change effects are already visible and will occur more frequently and pervasively over the coming decades even if global emissions are reduced drastically. Therefore, adaptation, which has long been neglected in favour of mitigation, will become more important.

Adaptation can take place on many levels, as it entails the individual lifestyle, community preparedness, technical equipment, as well as political cooperation.. Institutional adaptation as one part of adaptation ranges from traditional songs (informal institutions) that recall how to react in case of a natural disaster, over community insurance funds (semi-formal institutions), to full-fledged regional or even global organizations and mechanisms like the IPCC or UNFCCC is one (formal institutions). While in many cases, the technical part of adaptation can be sufficient, institutional adaptation is particularly helpful, where the “action situation” is complicated.

An action situation – in natural resources management – comprises the geophysical setting, the socio-economic and the institutional context. As for natural resources, the action situation becomes more complicated the more different users and different uses are involved. This is the case in transboundary river basins, where a number of sovereign nation states compete over a variety of uses (hydropower, irrigation, navigation, drinking water, fisheries) and try to manage a variety of threats (floods, pollution, scarcity) all stemming from the same resource. This, in turn, is closely related to climate change effects, because most of the predicted changes triggered by global warming have an impact on water. Water is the resource that will be most severely affected by climate change.

This article therefore raises and discusses the question:” How does climate change impact on complicated, conflict-prone action situations in transboundary river basin settings?” We have selected the Mekong basin as a case study. Within that we have focused on four already existing contested action situations: dam building, floods, water diversion, salinity intrusion. Each of these situations features a different set of users and uses. All of them, our analysis shows, will be affected by predicted climate change effects, although in different ways. We have taken into account all existing literature on climate change in the Mekong basin, cross-referenced the forecasted effects with the previously described action situations and analyzed how this impacts on the overall situation.

2) Institutional Adaptation and the Action Situation in Transboundary River Basins

2.1. Institutional Adaptation

So far, most research on institutions and climate change has focused on mitigation [O'Riordan and Jordan 1998]. Where adaptation has been addressed, institutional and regional issues were often neglected in favour of looking at individual adaptation actions on a local level or focusing on very global aspects of adaptation. [e.g. Adger 1999; Adger et al. 2003; ADB 2003; Downing/Patwardhan 2003; Klein/MacIver 1999; Parry et al. 1998; UNEP 2001].

Institutional adaptation can take place on various scales, ranging from traditional songs that recall how to react in case of a natural disaster, over community insurance funds, to full-fledged regional or even global organisations and mechanisms like the IPCC or UNFCCC. Generally, it can be said that the later, global scale institutions are "far away" from where climate change *effects* actually occur, while the former, the local institutions, are "far away" from the *information* on predicted changes , impacts on ecosystems and options for coping or adapting. What seems to be missing in many regions so far is an actor that can serve as a champion for institutional adaptation to climate change in a spatial unit that is big enough to retrieve information from global modelling, but small enough to allow for dissemination of this information to communities on the ground. Given that the majority of predicted climate change effects are water-related this could well be a river basin institution. Here, institutional adaptation could mean at least three things: enhancing technical capacities of concerned communities to deal with ecosystem changes, foster political cooperation between involved states, and create new institutional mechanisms to deal with uncertainty. While the first two options are within the range of existing river basin organisations, the latter one calls for a new breed of institutions, specifically designed with the increasing uncertainty and growing complexity introduced by climate change. These options have to be weighed in the light of the action situation and the way they might be altered by climate change.

Institutional Adaptation in a river basin context therefore aims to balance the need to sustain ecosystem with the demand for sovereignty and economic development of nation states lying in this ecosystem.In the Mekong basin, most studies concentrate on the situation in the delta. It is true that this is the region that will probably be most severely affected, but while Vietnam and Cambodia might have most of the problem they do not have most of the solution, which lies with the upstream countries, whose relevant actors have to adapt their production and livelihood patterns as well.. While Global Change is a worldwide phenomenon, its effects are perceived locally and regionally.

Institutional Adaptation means establishing mutually accepted mechanisms for coping with these changes on a local level without neglecting that interventions into ecosystems typically also affect other actors bound into this system.

2.2. Action Situations in Transboundary River Basins

The context of action situations after Ostrom (2005) in natural resources management is made of geophysical, socio-economic and institutional factors. Together, they define whether the involved actors have a good chance of managing a resource cooperatively or not. While the physical environment is hard to influence, except by large intervention into the ecosystem such as dam building, the socio-economic conditions can be at least partly changed, although they depend on a number of factors beyond the reach of involved actors, even if these are nation states. The institutional set-up in contrast can be shaped by the involved actors. It is typically a function of their relative power and their interest in a certain issue.

The geophysical context

In a transboundary river basin, the underlying hydrological setting is characterized by the properties of excludability and subtractability [Ostrom: 1991]. Three settings can be distinguished: an upstream-downstream-, a common-pool- and a public good constellation. A situation in which all involved parties have the possibility to substract from the other parties potential for usage would be called a common-pool constellation (two-way-subtractability). In an upstream-downstream situation one party can substract from the use of the others, but not vice versa (one-way-subtractability) [Haftendorn 2000; Le Marquand 1977; Waterbury 2002]. Theoretically, the upstream riparian could even cut off the downstream riparians from all the water running through its territory (one-way-excludability). If no party can be excluded and the resource is abundant, we speak of a public good.

Table 2: Public Good, Common-Pool and Upstream-Downstream: resource use configuration

		Subtractability of use (the good or resource diminishes by consumption)		
		not subtractable	**One-way-subtractable**	**Two-way-subtractable**
Non-excludability (difficulty of excluding potential beneficiaries)	not excludable	Public Good		Common Pool
	One-way-excludable		Upstream–downstream	
	two-way excludable			

[own illustration, following and extending: Ostrom, E 2005: 23ff.; Ostrom/Ostrom 1977: 12; Agarwal/Dupont 1999].

Public good situations are not conflict prone, because the benefit threshold can not be surpassed.

Common-pool and upstream-downstream constellations, in contrast, constitute the more complicated actions situations, because some of the desired uses might be mutually exclusive, e.g. (hydropower and flood protection, navigation and fisheries etc.).The more actors are in involved in one of these two situations, the more complex it becomes.

The complexity of an action situation in the context of water resources also depends on another feature from the geophysical setting: scarcity. Whether the resource is scarce or not can be measured according to different standards. The borderline might lie somewhere around the so called "water stress" benchmark. Water stress is part of a *technical* index to measure water poverty, applied mainly by the UN. Following this definition, a utilization rate of 20 percent of the yearly renewable resources indicates water stress, i.e. scarcity is likely to appear seasonally, regionally or locally. The more commonly used *demographic* index marks the beginning of water stress below a per capita availability of 1 700 m^3/year, chronic water scarcity below 1 000 m^3 and absolute water scarcity below 500 m^3[1] [Ediger 1997: 30f.; Gleick/Chalecki/Wong 2002: 98ff.; Hoekstra 1998: 44ff.]. Based on this index, experts anticipate water stress for between 40 and 60 percent of the world population by 2025 [Gleick 1998; Seckler et al. 1998; 1999: 29-42; Spillmann 2000: 154f.]. The 20 percent uncertainty range of this figure is contingent on the decision on whether to add or not to add China to the list of water-stressed countries [Gleick 1998; Chalecki/ Wong 2002: 106ff.].

The weak point of both indices is that they resort to nations as units of analysis, which, in many cases, is a too coarse resolution that obscures the real situation [Seckler et al. 1998: 15]. Again, transboundary river basin settings complicate the measurement of scarcity, because national statistics do not always tell much the situation in the respective part of an international basin that lies in certain area of a nation state. To complicate matters, resources use in a river basin includes much more than just a quantity of water. Hydropower, fisheries and navigation, to name just a few, are non-substractive uses whose potential can not be assessed by the same quantitative standard. Assuming a river basin perspective means taking into account all this different uses and all the different actors.

In this already highly contested field, climate change poses a new challenge. Undermining established patterns and adding uncertainty, it will be increasingly difficult to establish these kinds of absolute, quantitative standards for scarcity of a resource like water. Uncertainty might be the

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[1] A more sophisticated index that wants to measure water poverty by incorporating social and economic indicators resorts to the scientific debate only, probably due to its complexity [see: Sullivan 2002].

most genuine feature of climate change. While currently seen as a transitional problem of a science that is still in the making, it might soon turn out not to be an interim companion but a defining criterion of climate change itself. By augmenting the amplitude of potential events, climate change decreases predictability. Most arguably, this will induce actors to calculate with a higher *margin de manoeuvre* themselves. In the case of a common-pool-resource, for example this means that all involved actors increase their *potential* needs and decrease the *potential* availability of water resources, that means they will be calculating with a worse worst case scenario than before, which will invariably lead to a tougher stance in allocation and apportionment negotiations. Moreover, if every actor in a negotiation situation has to take into account a greater number of scenarios to formulate his bargaining strategy, the whole process becomes much more complex. Increasing uncertainty, we therefore argue, complicates action situations by hardening positions and proliferating scenarios.

Against this background, we suggest shifting the focus from a mere quantitative aspect of a resource to a qualitative, relative aspect related to the services incorporated in the use of a resource rather than its mere size. For non-substractive uses it seems more appropriate to speak of a benefit threshold, then of scarcity. When this benefit threshold is passed, a resource conflict will arise. However, with a focus on a number of services and a number of resource properties involved, opportunities for positive-sum games open up that have been previously hidden from a too simplistic, statistical, quantitative and absolute perspective. Institutional adaptation in the light of climate change, a first conclusion therefore reads, does not consist in establishing fixed benchmarks from which on redistribution has to come into effect, but rather means providing the analytical tools and communication platforms to deal with uncertainty, complexity and multi-service negotiations.

The socioeconomic context

For describing the socio-economic context of the action-situation, three characteristics have to be taken into account, economic growth, population growth and heterogeneity. Economic and population growth add as a stressor on the environmental services provided by a river basin.. During the 20th century per capita demand, on a global scale, increased by double the population growth rate[2] [Hoekstra1998: 25; Neupane/ Young 2001: 20], meaning that a doubling of population implicates a fourfold increase in total water demand, given, of course, a certain economic growth rate. A rapidly developing river basin will therefore have a considerable need for institutional adaptation mechanism, even before climate change comes into play.

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[2] Whereas the world population grew a little less than fourfold from 1.6 to 6 billion, water use increased by the factor 7 in the same period [Gleick 1998: 6].

With regard to heterogeneity, the underlying assumption here, inspired also by Olson's theory of groups [1971: 125ff.], is that in socio-economically homogenous regions *political* cooperation is more likely to occur than in socio-economically heterogeneous regions [see also Hackett 1992; Ostrom 2005: 26f.]. Important indicators are size, population, level of development, military strength, economic structure and economic power, the political system, ethnic division, historical and cultural background and, most specifically, the way relevant actors prefer to use the transboundary water resources concerned in their respective territory.

The heterogeneity of the group has also indications on how difficult it is to establish a common perception of the action situation, which in turn is important in order to arrive at commonly accepted problem solving approaches. Facing a high degree of heterogeneity therefore should induce institutions to arrange for rapprochement of perspectives first, before launching big programmes. Moreover, as rationales of various actors in the same action situation are difficult to assess, uncertainty about preferences increases with the degree of heterogeneity of that particular group. Last but not least, heterogeneity often also means asymmetry in the power equation. Whereas heterogeneous use preferences tend to exacerbate distribution conflicts in a common-pool-situation, asymmetries in the political power equation impact on upstream-downstream situations, in different ways of course, depending on whether the upstream or the downstream riparian is also the political powerhouse.

The institutional context

Finally, on the institutional side, it has to be considered to what extent the use of the contested resource is governed by rules and regulations to which all or most involved actors adhere. As for international waters, it has been shown that during the last 50 years cooperation over the resource use has outweighed conflict (Wolf et al. 1999). This well-founded analysis has contributed to a shift of attention from competition to collaboration over transboundary water resources. Since then, a huge body of literature has developed on river basin commissions, their virtues and drawbacks. The most common finding has been that existing institutional frameworks are often comprehensive in their approach, but almost always lack the mandate and the power to push through their own basin-wide agenda. Confronted with the comparatively new challenge of climate change effects, these institutions will face difficulties to extend their typically already weak mandate to this contested issue.

For all three, the geo-physical, the socio-economic and the institutional context, transboundary river basins with its multiple users and manifold uses hold a guarantee for complex action situations. With climate change most likely to introduce uncertainty, variability and complexity water-related issues in transboundary river basins appear to be particularly vulnerable to its effects. The following sections will analyse the potential impact of predicted climate change effects on already complicated and conflict-prone action situations in the Mekong basin.

3. Climate Change effects in the Mekong basin

The framework, developed in the previous section will be put to a test by applying it to the concrete case of the Mekong Basin The Mekong basin is a region where institutional adaptation to climate change will be of high importance. First, it lies entirely in the tropical and subtropical regions, which are expected to suffer most clearly and comprehensively from climate change effects. Second, as a developing region, its institutional capacities are comparatively low. The present problem pressure is too high to allow for capacity building which aims at tackling a problem that is not even fully conceived. The need for better institutions is obvious.

Furthermore, we believe that now is the right time to prepare for institutional adaptation in the Mekong. Among the transboundary basins that drain developing regions in tropical and subtropical zones, the Mekong basin is comparatively well studied, in water issues as well as, at a lower level, in the Global Change context. For one thing, this makes access to information easier in a field, where data availability is still staggeringly flimsy, all the more when it comes to modelling the future. For another, this makes exchange with other scientists, experts and practitioners easier and more promising. The available data and information is significant enough to allow for certain reliability.

3.1. The Mekong Basin

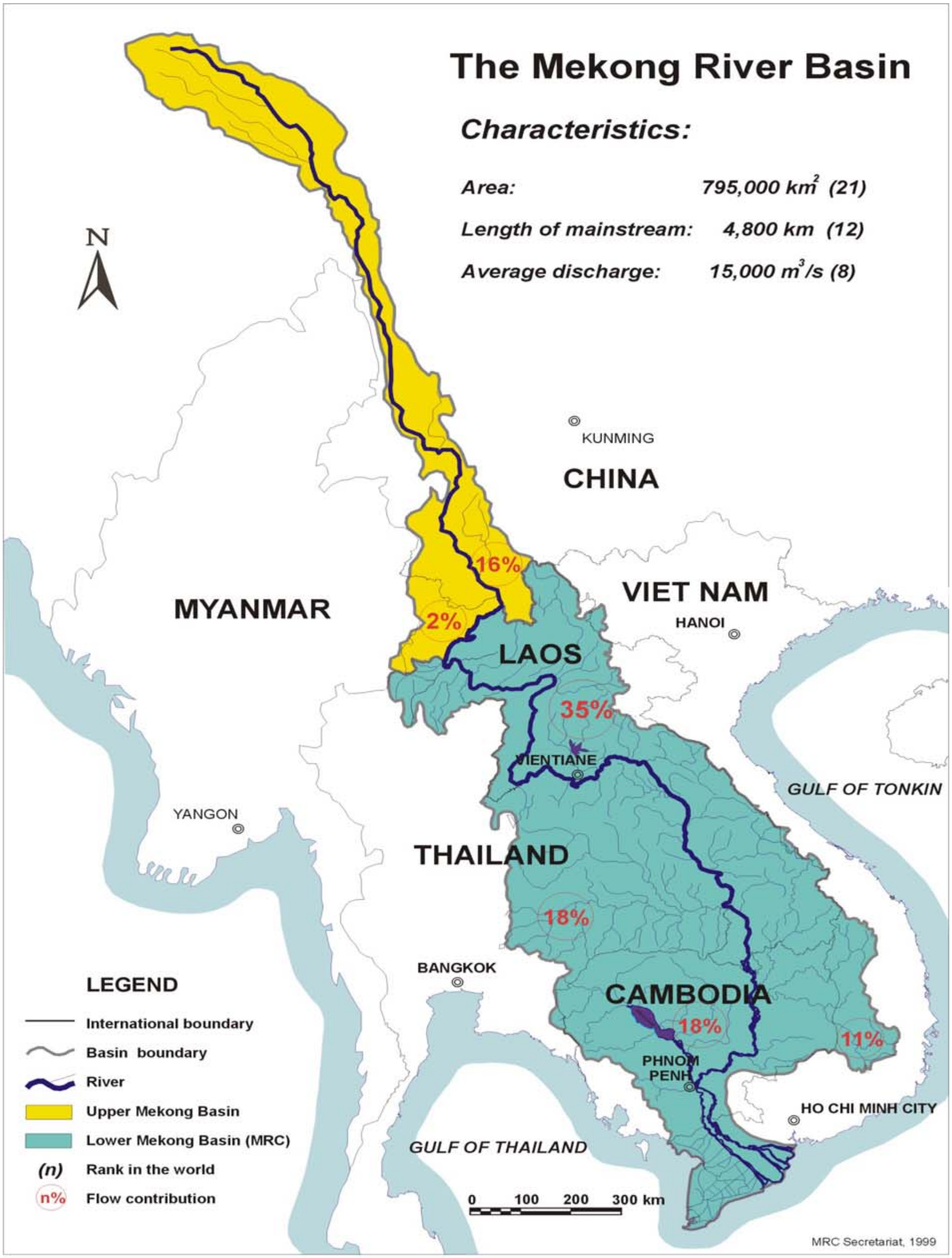
Originating from the rocks of the 5500m-high Tibetian plateau [see here and below: Dore 2003: 423; 1157f.; MRC 2005; Radosevich/Olson 1999: 4f.; Ringler 2001: 3-6], the Mekong traverses six countries – China, Myanmar, Laos, Thailand, Cambodia, Vietnam – before emptying into the South China Sea 4800km later. For almost half of its way and more than 80% of its drop in elevation the Mekong travels through Yunnan, creating a hydropower potential that matches the combined potential of the 5 other riparians [MRC 2001: 39ff.].

Despite its vast resource potential along the Lancang/Mekong, Yunnan only contributes 16% to the total run-off, similar to Thailand (17%), Cambodia (19%), and more than Vietnam (11%), but only half of Laos (35%)[i]. The Chinese government tends to play down the influence of dam construction in Yunnan, since only a small part of the total flow originates within China. This argument, however, ignores the fact that the total flow is measured in the delta, whereas in the Laotian capital Vientiane approximately 60% of the Mekong water stems from China [Goh 2001: 481; Menniken 2007: Osborne 2000: 231].

Agriculture accounts for 85% of the total water consumption [MRC 2002a: 7]. Although the water supply generally exceeds the water stress margin, scarcities appear locally and seasonally "because of uneven flow distribution, changes in water quality, and growing demand for water. […] Household use of water is expected to grow by 50 per cent over the next decade, water for agricultural use by 30 per cent, and water for industrial use by 100 percent" [Ibd.].

The Mekong basin is the dominating geophysical structure in mainland Southeast Asia and its rivers are virtually the only source of freshwater [Ringler 2001: 2]. Although the Mekong river basin is by no means water scarce, shortages might occur seasonally and locally. Moreover, it is not water exclusively that constitutes the huge significance of the Mekong for the basin population, but the ecological system based on it, which as a whole sustains around 80% of the population living in the lowlands of the basin:" Critical, for millions of people, who live in the lowlands, it is not the water alone that is the natural resource of greatest concern. Rather, it is the variability and complexity of an intact ecosystem – driven by annual flood pulse – that is the resource of immediate, and arguably highest, value" [Fox/Shennon 2005: 2]. Besides its quintessential significance for the survival of the people in the basin, the Mekong is attached to important cultural and religious values [Öjendal 2000: 10], traditionally hosting "hydraulic civilizations" [Wittfogel 1956].

Figure 1: The Mekong Basin



The main actor in transboundary water governance in the Mekong basin is the Mekong River Commission (MRC). The MRC, established in 1995 by four of the six Mekong riparians – Cambodia, Laos, Thailand, Vietnam – is the dominant player in transboundary water politics in the basin. It is, moreover, an epistemic community [Haas 1992], gathering, generating, processing and disseminating knowledge and information on all kinds of water issues. Thematically, it is not confined to water, but comprises all water-related fields like fisheries, navigation, hydropower, flood control, ecosystem, and others. The staff of its main administrative and technical body, consists (approximately) one half each of national and international experts, which means that linkages in both directions, to the international community and the political decision-making level of the four countries, are strong. In recent years MRC has incorporated climate change into its activities, mainly in the Environment, the Flood Management and Mitigation and lately also in the Agriculture, Irrigation and Forestry Programme. Last but not least, MRC holds one of the most advanced modelling capacities in the basin and is currently trying to integrate climate change accounts into hydrological modelling. It is therefore reasonable to address MRC as a key player in building institutional adaptive capacities to deal with water-related climate change effects in the Mekong basin.

The role, significance and potential of MRC in building institutional capacities to address Global Change will be examined by focusing on four water-related conflicts and the way they are supposed to be affected by Global Change. In the following sections, we will therefore present the status quo, the predicted socioeconomic change, climate change effects, before applying to four concrete actions situations.

3.2. Socio-economic Change

Approximately 70 million people currently inhabit the Mekong basin [see here and below: Haase 2002; MRC 2003; Öjendal 2000: 19-22; Ringler 2001: 7f.], arguably mounting to more than 100 million in 2025. Socio-economically, the riparian countries are extremely heterogeneous and differ from each other in every category including size, inhabitants, type of economy, living standard, political system and cultural background. The Mekong riparian countries are developing rapidly with economic growth rates between 6-7% (Cambodia, Laos, Thailand) and 9-10% (China, Vietnam).

This economic expansion will inevitably lead to an increase in water use and in the establishment of large-scale schemes. This, in turn, will induce distribution conflicts on the long run. Given the present growth rates, the economic output of the riparians will have doubled by 2020 and so will have the per capita demand. This calculation is supported by the relationship between population growth and growth of per capita demand of water, with the latter growing twice as fast as the former over the twentieth century. Population growth is at around 1.6% in the basin. If per capita demand grows twice as fast, in 2020 the population will have increased by 25% and each of those persons will use 60% more water than today. Based on a moderate population growth scenario, water availability per capita in 2040 will be half of that in 1995 (without factoring in any climate change effects) with more significant reductions in Laos (35% of 1995) and Cambodia (29% of 1995) but more absolute shortages in Vietnam and Thailand, both of which then will fall below (Vietnam) or close to (Thailand) the "water stress" threshold of 1700m^3/year [Hoanh et al. 2003]. Irrigation demand is said to double from 1995 to 2040 [Ibd.].

3.3. Climate Change in the Mekong basin

The water-related conflicts described in the following chapter will change their structure to varying degrees under climate change effects. Climate Change modelling for the Mekong basin is still weak. A total of 18 studies have been analyzed (see Annex 1) with regard to their forecasts on water-related climate change effects in the Mekong basin by issue (temperature, precipitation in dry and rainy season, droughts, floods, discharge, salinity intrusion/ sea-level rise and wind pattern) and by sector (agriculture, water resources, wetlands etc.) (see Annex 2). Although diverse in methodology, research question and thoroughness of investigation (see Annex 2) they give a surprisingly congruent picture of what the potential impacts of climate change on the hydrological regime will be.

Most studies agree that water-related climate change in the Mekong basin will be:

- Higher temperature and, therefore, higher evaporation.
- Overall rainfall remains roughly the same, but change seasonal patterns.
- Less rainfall in the upper basin, but compensated by melting glaciers.
- Shorter wet season, longer dry season.
- Increasing variability.
- Increasing discharge
- Rising sea-level.
- Changed flood pattern.

These predicted changes will have a strong impact on the hydrological regime and, therefore, overall socio-economic, political and institutional setting of the Mekong basin. In order to assess the extent of impacts, they will be cross-referenced with 4 already existing water-related conflicts.

4) Four complex action situations in the Mekong basin under climate change

4.1. The dam cascade in China

China, the upstream riparian, is building a **cascade of eight dams** along its stretch of the Mekong envisaged to produce approximately 15.000 MW by 2017, worrying the majority of policy-makers and resource users in the downstream countries. For one thing, China increases its threat potential vis a vis the lower riparians. With the dams in operation, it could easily withhold a considerable amount of water for a considerable duration in order to put pressure on the downstream countries also in non-water issues.

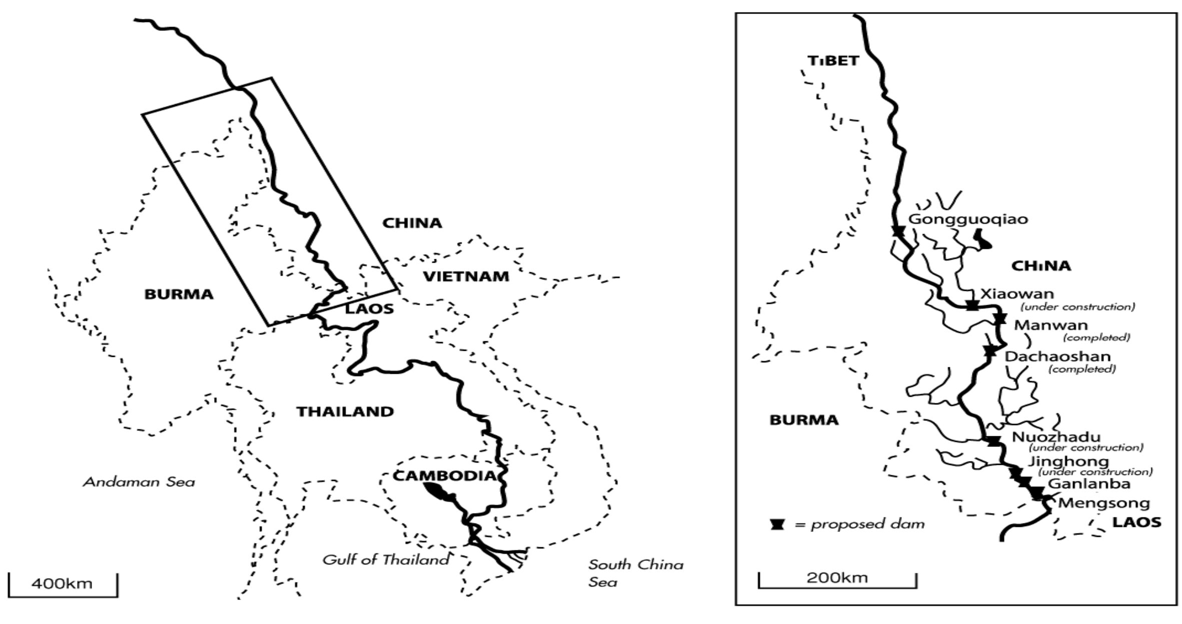
Second, the generation of hydropower alters the flow. While some experts claim that the Chinese dam operations might even out the flow, which is presently bound in a seasonal cycle, concerns are raised that exactly such a flattening of the flow would distort downstream crop production, which is highly adapted to the seasonal flow [Miller 2005]. Besides this, it is not likely that China will do anything to contribute to a sound flow regime downstream, but rather just use the water as it sees fit for energy production, which in turn might soon aggravate the flooding downstream.

Although only two dams are currently in operation, negative downstream impacts, especially on fisheries, have already been reported. These are to increase with the growing storage capacities of the dam cascade. Last but not least, the water stored behind the dams might in the future also be used for irrigation, not only altering but also diminishing the flow of the Mekong.

In this upstream-downstream situation, quantitative scarcity is not yet an issue. From an ecosystem services perspective however, it is obvious that a number of different services stand in competition with each other, namely hydropower generation, irrigation, flood protection and fisheries. Uncertainty is high, also, but not only due to climate change. A forecasted reduction of annual rainfall in the upper basin will have impacts on the lower riparians, but it is not yet clear of which kind. A rising number of weather extremes that is also predicted will equally alter the situation to an unknown extent. Moreover, considerable uncertainty comes from the intricate hydrological setting of this conflict, involving the whole basin, six different countries, a number of different uses and uncertain political developments. The heterogeneity of the group is obviously large and, in this case, to the detriment of the lower riparians who face a hydrological hegemon, who also constitutes the political powerhouse.

Finally, the institutional context is not benign, since the China is not a member to the MRC and the process of rapprochement among the downstream riparians within the framework of MRC has not advanced to a stage where they could act as one force vis a vis China (Menniken 2007).

Figure 2: The Mekong/Lancang Dam Cascade



Mekong River basin. Box highlights section of river where China is constructing 8 dams

Source: International Rivers Network (IRN).

The **China problem** will change the existing conflicts quantitatively and qualitatively, with a high degree of uncertainty under Global Change effects. This uncertainty is mainly due to China´s upstream position, meaning that the whole set of countries, uses and ecosystems downstream depend on what happens in Yunnan.

Given the predicted decrease of rainfall in the upper part of the basin, China´s threat potential increases. Moreover, it becomes more attractive for Chinese farmers to change from rainfed to irrigation agriculture and use the water stored within the dam cascade to do so. This, in turn, would reduce the available water quantity further downstream.

With decreasing predictability of rainfall patterns, flow regulation will become more important. At the same time, with all eight dams in operation, flow regulation will be entirely in China´s hands. Whether flow regulation upstream and flow regulation downstream will run on the same premises has to be questioned. If it turns out to be true that under climate change effects, extreme weather events will occur more frequently, with the technical capacities at hand in China, the lower riparians will always have a problem when such a extreme event, be it drought or flood will take place basin-wide. In case of a basin-wide flood, China will open its sluice gates, aggravating the situation downstream. In case of a basin-wide drought, China will store as much water as possible, again to the detriment of the lower riparians.

The most immediate response to these threats might be an increased dam building activity in the lower basin to enhance the respective storage capacity. This, in turn, might induce a whole set of new conflicts among the downstream riparians. On the other hand, facing an even more extreme seasonal pattern, China´s dams might help to even out the annual mean flow. One way or the other, nothing points at cooperative management of these coming problems. China is the single upstream riparian and political powerhouse, which will in the medium future face shortages against the backdrop of weak institutional and legal provisions. Here, climate change acts as an additional stressor in an already disadvantageous situation as well as the creator of new conflicts whose shape is not yet visible.

4.2. Salinity Intrusion in the Vietnamese Delta

Salinity intrusion in the delta is a natural process. The reduction of flow anticipated due to climate change, however, increases the distance that the salinity intrusion goes (normally up to 60 km) or might lead to an earlier start of salinity intrusion which negatively impacts on the crop production patterns. With the delta being the rice bowl, not only of Vietnam but of the region, and Vietnam being the second largest exporter in rice on the world market, stakes are high. Rising salinization would induce Vietnam to attack the water use policy of the upstream countries. Cambodia is also affected. Salinity is slowly intruding southern Cambodia and threatening freshwater fisheries.

Presently only Vietnam and Cambodia are affected. The reduction of salinity intrusion in Vietnam is also beneficial to Cambodia, making this a common-pool problem for these two countries. The question therefore is who pays what for the provision of salinity control schemes Water scarcity is so far not an issue. However, the related services are moving closer to the benefit threshold defined by the current productivity of fisheries and rice farming in the delta. Uncertainty about the hydrological setting is comparatively low, since the delta is well-studied, the causes, effects of and also the solutions to salinity are apparent. The group of actors is more homogenous than in the other conflicts, although Vietnam and Cambodia have an intricate history of cooperation and conflict. The MRC provides a formidable platform for negotiating an allocation scheme for the provision of control mechanisms.

Salinity intrusion (SI) is aggravated in several ways by predicted global and climate change effects. Socio-economically the lasting economic expansion will increase the water needs of all Mekong riparians to an extent that might increase salinity intrusion in the dry season by withdrawing too much water further upstream. Furthermore, Laos with its plans to build a number of dams, although only on tributaries, will have an impact on time and scope of SI. This means that two new players will enter the action situation over the coming decade or so.

Climatically, a rising sea-level clearly leads to more SI at the mouth of the river, if the discharge of the Mekong remains unchanged. Predictions of global sea-level rise vary greatly between 18 and 59cm [IPCC 2007] and are not yet adjusted to regional conditions, but clearly in a delta as flat as the Mekongs´ every centimetre counts. Hydrological modelling shows that at his last kilometres towards the sea the Mekong even courses up a tiny slope before literally falling into the South China Sea. This, however, also means that once the sea-level has risen to an extent where it overcomes this mini-slope, salt water intrusion will increase significantly within a very short time period.

Second, a reduction of the flow, induced by more or less constant rainfall and increasing evaporation due to higher temperature further exacerbates the situation. Overall, the river run-off is predicted to decrease by 6% in 2050, so that, together with sea-level rise, less freshwater will meet more saltwater in the delta.

Third, changing seasonal patterns leading to a more intensive but shorter flood and a more intensive and longer drought season might trigger an earlier start date of salinity intrusion. Salinity intrusion under the climate change effects forecasted will therefore affect Vietnam and Cambodia earlier in the year, be more intensive and go deeper into the country. This would be aggravating an existing conflict but it might also add a new dimension by internationalizing the problem: the Mekong delta is the rice bowl of Vietnam Decreased rice production in the delta therefore will have effects clearly exceeding the Mekong basin. Fortunately, technical measures to control or even prevent salinity intrusion exist. Whether countries, causing part of the problem upstream, will contribute to installing such control mechanisms downstream is another question.

In general, this means that the action situation is changed significantly. First, new actors are introduced, adding an upstream-downstream component to this hitherto common-pool-situation. The benefit threshold will be exceeded for all involved services. Uncertainty of the hydrological setting increases through the impacts of climate change. The group becomes more heterogeneous. On the positive side, in the absence of China, whose actions will prove largely irrelevant for the delta, the remaining countries have a common forum to solve such a problem, the MRC. Moreover, the Mekong basin depends on the products of the delta and no country outweighs the others in terms of political power.

4.3. Water Diversion in Northern Thailand

Thailand and Vietnam are the two major economic forces of the lower Mekong basin. Both dispose of a remarkable agricultural sector, which is producing for domestic needs as well as for the world market. Recently, to compensate for shortages in other basins, Thailand has revealed plans to divert water from the Mekong basin in the dry season and use it out of the basin. The Kon-Ing-Nan and the Khong-Chi-Mun schemes shall serve to irrigate fields in the dry Northern and North Eastern territories. This does, of course, not go uncontested, especially not by Vietnam, Thailand´s co-hegemon in the lower basin.

The water diversion conflict, although structured by an upstream-downstream configuration revolves around a common-pool-resource. Although Thailand generally comes first along the mainstream of the Mekong, it is no clear upstream riparian. For one thing, it is downstream to China and, in parts, to Laos, contributing to a cognitive disposition to acknowledge downstream problems. Second, even Vietnam is upstream to Thailand along two tributaries of the Mekong. Third, Thailand benefits from the productivity of the delta and would be negatively affected from a breakdown of the delta's economy.

This common-pool-situation is threatened by looming scarcity. Although so far water is enough, the increasing needs of both countries, who have been economic overachievers for almost two decades now, will bring them close to or over the benchmark of 1700m² per year and capita. Uncertainty about thy hydrological regime is further aggravating the problem, leading both countries to calculate with a wider range of scenarios. Although culturally and politically heterogeneous they are increasingly economically intertwined. Both need the water mainly for irrigation, making the issue less complex, but the competition fiercer in the light of looming scarcity.

The conflict arising from **Thailand´s plans to divert water** in the dry season and use it out of the basin will grow if the predicted change of rainfall pattern is going to take place. As a general rule, **water distribution** will in many cases turn out to become much more contested in the Mekong basin in the future, due to effects of socio-economic and climate change. The more immediate stressors here are economic expansion and population growth, which will together significantly decrease the per capita availability vis a vis the per capita demand. The increase in pesticide use in agriculture and increasing industrialization processes will deteriorate water quality and, in doing so, further reduce the available quantity for certain uses. This situation will then be aggravated by the described climate change effects. China will have less water through rainfall and consequently withdraw more water for agricultural and industrial purposes. Thailand will have less rainfall and more evaporation and consequently withdraw more water. The dry season will become longer and dryer, which makes water storage more important. The rising sea-level will lead to increased saline intrusion in the delta leading to an increased need for water in Vietnam. In this process water will necessarily run short in certain regions and in certain times of the seasonal cycle.

If the dry season becomes longer and dryer, dry season withdrawal and out-of-basin transfer becomes even more important to Thailand and even more harming to Vietnam. If it also right to assume then that the salinity intrusion problem will become more severe under sea-level rise, these two conflicts will be mutually reinforcing. Since from a combination of these two problems, it looks as if Thailand and Vietnam were going to have a problem with each other in the near future, institutional solutions might aim at bringing in the other two states, which still have some water to spare even in 2040 and even under climate change stressors, Laos and Cambodia (see chapter 6).

4.4. Floods in the lower Mekong basin

Unexpected (in scope and time) **floods** engender adverse economic, ecological and social effects, by destroying natural habitats, flooding fields, destroying livelihoods and displacing people. The Lower Mekong Basin has been facing a series of severe unexpected floods over the last few decades with a preliminary peak in 2000, when Cambodia and Laos were badly hit, losing more than 10 percent of their annual harvest [MRC 2003: 275f.]. Although historical accounts of water-levels of the twentieth century show no obvious pattern of higher or lower mean flows, recent decades have witnessed a proliferation of extremes.[3]

Here, the most important environmental service is protection from floods. As the events of 2000 have clearly shown, the service of flood protection is undersupplied, i.e. it is scarce. This might in

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[3] Interview with Hans Guttman, former Head of the Environment Programme of the Mekong River Commission.

part also be due to the complex hydrological setting. Floods are by nature difficult to assess and always underlie a certain degree of uncertainty, which however, is decreasing within the lower Mekong basin thanks to growing modelling and forecasting capacities. The group of actors is rather heterogeneous. Since the flood issue is addressed within the MRC framework and the Flood Management and Mitigation Programme is the best endowed component of MRC in financial terms, chances are cinreasing that the involved actors will become more homogenous over time and establish a common problem perspective.

Most likely, the envisaged patterns of a shorter, more intense wet season will increase the **number and severity of floods** with all the related problems. As pointed out earlier, much will also depend on ongoing dam-building activities in the basin. If extreme floods occur basin-wide, a normal upstream dam policy would be to open the sluice gates. Moreover, the fragile and highly important ecosystem revolving around the Tonle Sap and its reverse flow is threatened by changing patterns of rainfall and floods. A ceasing reverse flow would be tantamount to the extinction of a number of species and a sudden reduction in Cambodian fisheries, which is currently contributing more than 5% to the country´s GDP.

Uncertainty is increasing in this field, because it is influenced by a number of factors that are beyond the control of a single actor. Dam building activities as well as water diversion and irrigation schemes will have a considerable but so far unspecified impact on flooding, making this an issue for which new institutional mechanisms have to be established, in order to make better use of already existing techniques, such as flood control and early warning systems.

5) Institutional adaptation to climate change in transboundary river basins

The application of the framework on the four transboundary water related conflict has shown that climate change will alter these action situations more often than not, to the worse, either by exacerbating existing conflicts or introducing new ones. Uncertainty increases, formerly disconnected problems connect, new actors enter the arena, the amplitude of potential events is widening. Adaptation to deal with these changes can take place on three different levels:

- Technical: Provision of a set of technical measures
- Specific institutional adaptation: Provision of ground for political solutions
- Generic institutional adaptation: Adjusting to uncertainty by enhancing flexibility

First, existing institutions, and here mainly the MRC, should embark on a policy of pre-emptively establishing technical solutions for predicted climate change effects. To make these efforts no-regret options, it is important to identify such cases where climate change effects only play an aggravating role to an already existing conflict. In such a case, as for example with salinity intrusion, the application of technical measures to alleviate the problem will turn out to have a double benefit if the hydrological models once fed with climate change information turn out to be accurate.

Second, and conversely, where climate change is supposed to create an entirely new conflict or greatly changes the structure of existing ones, efforts should remain on the theoretical, non-tangible side until higher consensus has been established on what the real effects will look like. The China dam cascade, for example, comes along with such an intricate set of repercussions that, particularly in combination with the equally uncertain climate change effects, no premature action should be taken. Rather, it will be helpful to strengthen political cooperation on the related issues as a mode of preparation and awareness-raising.

Third, uncertainty itself will very likely not be greatly reduced in the coming decades but rather be established as a common feature of climate conditions. Increasing amplitudes in weather events therefore have to be matched by increasing amplitudes of institutional preparedness and organisational flexibility. This, however, can not be done without the intermediate step of enhancing political cooperation.

With technical measures ready at hand and the new institutional breed far away, political solutions to predicted climate change effects appear to be the most important next step in institutional adaptation to climate change. The complexity and interdependence of issues standing out from the foregoing analysis, which only concentrated on a small sample of existing problems requires complex and interrelated solution approaches.

While concrete effects of climate change in a given region are still contested, it is agreed that maters will become more complicated. If Thailand and Vietnam, for example will further boost their water-based agriculture and industry and climate change will, one way or the other, decrease available quantities, emerging tensions will not only effect the two immediately involved countries but also Laos and Cambodia, who depend on their bigger neighbours politically as well as economically. In such a case, Laos and Cambodia would have to be involved in the search for solutions since their water availability will still be clearly above the water stress threshold. In exchange for releasing, or even diverting more water to Thailand and Vietnam, Cambodia might receive some support in stabilizing the Tonle Sap ecosystem and preparing for floods, whereas Laos could need funds as well as markets for hydropower, which in turn would decrease dependency on Chinese hydropolitics. For such complex negotiations, again, it will be helpful to identify those situations that are comparatively easy to resolve and help to build up some trust first.

6. Conclusion:

As this analysis reveals, climate change is doing three things to the Mekong basin: it increases risks, it increases uncertainty and it increases complexity. Taking no more than water-related climate change effects and no more than four hydropolitical issues, a set of potential conflict emerges. China might be able to dominate the basin even more openly, Thailand and Vietnam will confront economic limitation, enter the group of water-stressed countries and, most threateningly, are pushed into competition with each other, Cambodia has to fear unprecedented floods, possibly alleviated, possibly buttressed by Chinese dams, and a total breakdown of the Tonle Sap. Laos, whose prospects are not too dim in hydrological terms, might be crushed between all these problems and the related ambitions and emerging conflicts. The case of Laos shows, that not only the problems but also most of the potential solutions, at least those on a political, institutional level are interrelated. Whereas floods, salinity intrusion, water diversion and dam building under climate change effects could, theoretically, also even out the effects of each other, it is more likely that they will be mutually reinforcing. This, however, might also be true for the cooperation potential. The water distribution conflict between Thailand and Vietnam that is likely to turn from a relative to an absolute one under climate change effects, can only be reasonably dissolved by bringing in the water quantity potentials of Laos and Cambodia. These, in turn, might want the support of the bigger neighbours for medium- or large scale hydropower, irrigation or navigation schemes. Such a trade-off could then also enhance the overall capacity of the lower riparians vis a vis China, whose power will only grow, if the Mekong flow reduces.

Sections 4 and 5 discussed how these processes of institutional adaptation to climate change effects might look like if processed through the Mekong River Commission or any useful extension systems of it. As consensus on the *modus operandi* is still to be established, steps have to be taken carefully. Within the current institutional framework in the Mekong basin, the MRC seems most appropriate and sufficiently equipped to pursue some technical operations, such as salinity intrusion and flood control, water storage or hydropower development. For political solutions of the kind of complex multi-level trade-offs, MRC is also suited, but currently lacks the political support from the member countries. Unless the climate change issue is more comprehensively addressed in the basin and more scientific consensus on potential threats has been established such agreements have no chance of coming about. The more important task in this field therefore is to raise awareness, screen the institutional landscape, bring together, compare and adjust existing concepts of institutional adaptation.

As for uncertainty, arguably a new breed of institutions has to be developed that combines flexibility with alertness. Such institutions have to be prepared for a much wider range of events at the same time, without actually working on them constantly. Such an increasing institutional amplitude is only efficient to come about if uncertainty has been more clearly established as a lasting feature of climate change (as paradoxical as this might sound) and will form hopefully form an innovative branch of research on institutional matters in the coming years.

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Manifestations of Climate Change in the Mekong River Basin through Projected Changes in Climate Variability

Articles/Methodology	Locality	Temperature	Rainy Season	Dry Season	Drought	Wind Pattern	Run-off and Discharge	Flood	Salinity Intrusion/Sea-Level Rise
IPCC (Southeast Asia)	Asia (SEA)	Warming (increase) with little seasonal variation. CSIRO model centred on IndoChina peninsula demonstrated potential for significant local variation in warming, particularly tendency for warming to be significantly stronger over the interior of landmasses than over surrounding coastal regions.	Increased monsoonal precipitation in the summer. Subcontinental boreal winter precipitation is very likely to increase in Tibetan Plateau. Northern part of SEA region will be affected by any change in tropical cyclone characteristics, likely increases in tropical cyclone intensity.	Rainfall variability will be affected by ENSO changes and its effect on monsoon variability					
Suppakorn Chinvanno	whole MRB	Daytime temperature higher by 1-3oC esp. in Jan - May. In Jun-Aug, temperature change will be smaller and less systematic. July: most of Lower Mekong will be cooler. August: intra-seasonal rain lag occurs, daytime temp. will be lower. Sept-Dec: generally cooler by 1-3 degrees Celsius esp. in Northern and Eastern Highlands. Nights will be warmer for most part of the Mekong and for most months except in Sept and Dec when central parts of Basin will be slightly cooler by about 1-2oC.	Will experience the seasonal shifting and change in rainfall distribution over the year. Rainy season will begin in June instead of May and last until November .			Prevailing wind pattern will be changed as timing for migration of ITCZ will be differed. Average wind speed over land will be only slightly changed	Run-off in Upper Mekong will be reduced and so does the erosion along mountain slopes = better water quality in terms of suspended solids	The reverse flow from the mainstream together with the more local rainfall will make flood during the late rainy season unavoidable. Possibility of more severe flood in the Korat Plateau and the Southern Lowland areas as there will be a significant increase in rainfall esp. in Sept-Oct.	
	Northern region of the basin (Yunnan)				Will have significant less annual rainfall by 20%				
	Eastern Highland	mostly affected by increasing temperature	Eastern Highland: may experience a longer and dryer season but wetter rainy season; Rainy season will be shorter by about 2 months as the season onset will be delayed from Mar to Apr; Early and late season rain peaks will be more prominent as the rain rate during these peaks (May-Jul and Sept-Oct) will be about 20% and 60% higher, respectively; The rain in August dry spell will be reduced by about 30%; Total rainfall will be slightly increased from 110 bcm/yr to about 114 bcm/yr or about 3%	The rainy season offset will be earlier from Dec to Nov.					
	Thai-Malay Peninsula				more arid in Jun-Aug				
	Sea Area, esp. the Gulf of Thailand and Andaman Sea		Will receive more rain	Dry season months (Dec-Apr) will be the same or slightly dryer except for the southeastern part toward the mouth of the Mekong		In sea areas, the wind speed will be higher most of the year			
	Lancang Basin		Over the wet season (May-Aug) rainfall will be significantly lower	Rain rate during the dry season months (Sept-Apr) will be generally the same	Less rainfall throughout the year but the season pattern may continue to be the same as of today; from 109 bcm/year to 87 bcm/year or about 20% reduction. Lancang Basin is the only part of Mekong Basin where annual rainfall will be significantly reduced				
	Northern Highland		May experience shift in season pattern; slightly less rain during the first 2 months of the wet season (May-Jun) but toward the last 2 months of the season (Sept-Oct), rainfall will be significantly increased; tendency that rainfall may be reduced during mid-rainy season; annual rainfall, however, will remain to be the same at about 114 bcm/year.						
	Koral Plateau		May also experience significant shift in season: Rainfall will be increased during the early months of the wet season esp. July; Dry spell between early season rain peak and late season rain peak will be reduced from 3						
	Lowland		Rainy season will be shorter and wetter. Wet season will be reduced by about 2 months with a clearer lag between peaks; Sept will have particularly more rain with monthly rainfall increased by about 80%. Total rainfall will remain to be the same at about 197 bcm/yr.	Dry season will be dryer and longer					
Arora and Boer	whole MRB						Decreased mean annual flow (river discharge); But little change in seasonality	Decreased flood magnitude	
AIACC Regional Study AS07				Significant shift in season pattern in most part of the region				Chance of flooding is likely to be the same as today as there is not much difference in total rainfall than today	
				Significantly reduced rainfall in the northern part of the region				Chance of landslide may increase as the rain in rainy season is likely to be heavier	
Aerts et al (2006)		0.85 degree Celsius increase (2001-2099)	6.6% increase in precipitation (2001-2099)				Increase in mean decadal discharge of 37% as response to projected GHG forcing scenario as compared to natural climatic variations of the last 9000 years		
IWMI		Average temp will increase by +1 degree Celsius in 2010-2039	Average rainfall will decrease by -20mm in 2010-2039		More drought and water shortage in dry season in lower Mekong sub-basins			Higher floods in rainy season in lower Mekong sub-basins	
		Increase by 3-4 degrees Celsius in 2070-2099	Increase by 60mm in 2070-2099						
Jeffrey Jacobs		Increase of 0.2 degrees Celsius to 2-4 degrees Celsius for the entire Lower Basin							
Hoanh, et al		Mean temperature in the whole MRB will increase from 24.3oC in 1961-90 to 25.3oC during 21010-2039 in both scenarios A2 and B2.	Compared with the baseline 1961-90, during 2010-2039, mean precipitation in different sub-basins varies from about -6% to +6% in both A2 and B2 scenarios.			High-temperature winds		Tropical cyclones, frequency and related floods may increase	The extent of the intrusion of saline water in the Mekong Delta depends on the magnitude of the dry-season flows from upstream and the level of abstractions for irrigation. The area is clearly sensitive to any future changes in river flows.
		During 2010-2039 in scenario A2, mean temperature in every sub-basin will increase about 3.7% to 4% compared with the baseline 1961-1990. Same increase is found during 2010-2039 in scenario B2.	However, for whole MRB, mean precipitation during 2010-2039 only varies by +0.2% and -0.2% in scenarios A2 and B2.						
			Seasonal shifts in weather; ENSO phenomenon which influences the weather and interannual variability of climate and sea level esp. in the western Pacific Ocean and South China Sea around the MB						
SEA START RC and the study of CC in LMB	Lower Mekong River Basin (Lao PDR, Vietnam and Thailand)	The region tends to get slightly cooler under climate condition at CO2 concentration of 540 ppm but will be warmer under climate condition at CO2 concentration of 720ppm.	Increasing precipitation by 10-30% throughout the region under future climate condition at both CO2 concentrations of 540 and 720ppm, especially in the eastern and southern part of Lao PDR.	Summer time in the region will be signifantly longer in the future. Hot days (with max. temp. of 33oC) will increase by 2-3 weeks. Cool days (min. temp of 15oC) will reduce by 2-3 weeks.					
Integrated Basin Flow Management Specialist Report (IBFM 3)							Results from the SWAT model test runs show that climate change may increase the water yield in LMB, and subsequently increase the mainstream and tributary flow in the future periods. However, this effect does not occur in the whole LMB, but vary from sub-basin to sub-basin.		
AIACC Working Paper No. 40 October 2006 "Climate Risks and Rice Farming in the Lower Mekong River Countries"	Lower Mekong River Basin		Increasing precipitation throughout LMB ranging from no change to more than 500mm/year (up to approx. 25%) with greatest increases projected for Lao PDR. The region would have higher precipitation within the rainy season implying potentially greater intensity of rainfall (shorter rainy season but wetter).					The projected higher-intensity precipitation for the rainy season is likely to increase the magnitude of floods in the region and possibly also the frequency of flooding.	
AICC Report, Anond Snidvongs of SEA START RC	Southeast Asia with focus on LMB	Average temperature in the region tends to be slightly cooler under 540ppm concentration but will be warmer under 720 ppm. Range of temperature change is 1-2oC. The hot period of the year (summer) will extend longer and the cool period (winter) will be significantly shorter.	The length of rainy season would remain the same but with higher rainfall intensity				These changes in climate pattern will result in higher discharge of most of the Mekong River tributaries, which is higher in proportion to the increase in precipitation.		
IPCC Working Group II	Asia	Warming is least rapid, similar to global mean warming in South East Asia. Warming would be significant in Himalayan Highlands including the Tibetan Plateau. Tibetan Plateau glaciers are projected to disappear with 3oC temp rise and no change in precipitation. If current warming rates are maintained, glaciers are likely to shrink at very rapid rates from 500,000 km2 in 1995 to 100,000 km2 by 2030s. An increase of 10-20% in tropical cyclone intensities for a rise in SST of 2-4oC is likewise projected in E, SE and S Asia.	Sub-continental mean winter precipitation will very likely increase in Tibetan Plateau and likely increase in SEA. Summer precipitation will also likely increase in N, S, SE, and E Asia. Increase in intense precipitation events also projected in S, E and SE Asia along with an increase in interannual variability of daily precipitation in the Asian summer monsoon.			Amplification in storm-surge heights could result from the occurrence of stronger winds, with increase in sea-surface temperatures and low pressures associated with tropical storms resulting in an enhanced risk of coastal disasters along coastal regions of E, S and SEA countries.		With a 1m rise in sea level, 15,000-20,000 km2 of Mekong River Delta are projected to be flooded.	In coastal areas of Asia, current rate of sea-level rise is reported to be between 1-3mm/yr, marginally greater than the global average.
CSIRO Climate Change in the Asia/Pacific Region	Asia/Pacific	Temperatures throughout the region are projected to increase over the 21st century. Low and high scenarios of warming range from approx. 0.5 to 2oC by 2030 and 1-6oC by 2070. Tropical cyclone intensities increase in response to higher sea surface temperatures.	Patterns of rainfall change in summer (JJA) and fall (SON) resemble the annual pattern with increasing rainfall throughout much of the region, consistent with increased rainfall from the summer monsoon.	Projected changes in rainfall vary significantly from one region to another. Central estimate indicates reductions in winter (DJF) rainfall of less than 10% by 2030 for southern Asia, extending from Pakistan across India, SEA and SE China. These reductions in rainfall increase to approx. 20-30% in southern India and SEA by 2070 generally suggesting increased winter aridity associated with the northeast winter (DJF) monsoon. This pattern of rainfall reductions persist through spring (MAM).	Monsoon variability is also tied to the El Nino Southern Oscillation, with drought risk increasing during El Nino events, yet there is little agreement among climate models with respect to how future climate change may alter the frequency or intensity of El Nino events.				Simulations suggest increases in global sea level of 3-16cm by 2030 and 7-50cm by 2070 (but Greenland ice sheet melting not accounted for). Sea-level rise is perhaps the region's greatest vulnerability which all studies indicate will erode and inundate coastlines and wetlands and displace communities.
ADPC Bangkok "Climate Change and Development in Vietnam"	Vietnam	Increase by 0.3 to 2.5oC by year 2070. Inland area (NW, N and Tay Nguyen Highland) will experience highest increases of 0.5oC in 2010, 1.8oC in 2050 and 2.5oC by 2070. Coastal area temp of Central and Mekong Regions will rise by 0.3oC in 2010, 1.1oC by 2050 and 1.5oC by 2070. Climate change may lead to an increase in warmer sea surface temperatures in higher latitudes and a resulting increase of typhoon activity in North Vietnam.	RAINFALL: In Southwest monsoon areas, rainfall may be altered by ±5%. Areas affected by Northeast monsoon may experience increases of rain by up to 10% from 2050.			The climate is expected to be warmer, approximating conditions that exist during El Nino years and allowing winds to retain their high speeds for a longer period during each typhoon. Intensity of storms may be higher in general and particularly so during El Nino years.		Due to rise of river beds and backwater effects (attributed to a base of 1m sea-level rise), 17M people will be subjected to annual flooding where over 14M of these will be in Mekong Delta provinces	Sea levels may increase by 9cm in 2010, 33 cm in 2050, 45 cm in 2070 and 1m in 2100. This will have serious implications for Vietnam with its extensive coastline. Studies show that sea levels around Vietnam have already risen 5 cm over the past 30 years.

Impacts of Climate Change on Water-Related Sectors in Mekong River Basin

Articles/Documents	Water Supply	Human Settlement/Urbanization	Natural Wetlands	Agriculture		
Suppakorn Chinvanno	Upper Mekong (esp. Yunnan): Significant reduction in annual supply of water but rainfall in dry season will not be much reduced so communities may not feel much different in water availability during the dry season	If annual inundation occurs longer or shorter than normal period, these wetland ecosystems as well as their functions and services would be affected	Tree species in natural wetlands (flooded forests, riparian swamps and lakes) in most parts of Mekong River Basin will receive minimal impacts of climate change	Crop production esp. rainfed rice cultivation will be strongly affected by hydrological change caused by atmospheric CO_2 elevation.		
	Upper Mekong: Irrigation system may suffer from water shortage as peak rainfall during rainy season will be reduced by 20%	Some communities, such as those based on capture fisheries, may gain benefit from the optimal increases of flood level and duration but detailed impacts has to be studied at a community level.	Flooding duration may be changed or shifted slightly but these may be small enough that the ecosystem can cope with	Season shift and change in precipitation pattern may have strong impact on the crop yield and crop cycle as radiation, water level and rainfall distribution may change over time		
	Run-off in Upper Mekong will be reduced and so does the erosion along mountain slopes = better water quality in terms of suspended solids	Less erosion potential in Yunnan Province due to less rain implies that the soil will be more stable and land protection cost may be reduced.	Lancang: Some of the natural wetland may be dried due to less rainfall	The generally shorter and more intense rainy season implies that rice varieties and other crops currently grown in each area may not be suitable in the future.		
	Korat Plateau and Southern Lowland: Shorter rainy season and longer dry season by about 2 months but total rainfall over a year will be the same or slightly higher so overall impact on water supply may not be so great provided that community has sufficient storage of water for the longer dry season.		Mangrove and Melaleuca forests in the delta area of the Mekong may be affected by changing hydrology to some degree, for example, ambient salinity of water. If the dry season is longer in this region by 2 months, some of the trees may not thrive.	Irrigated farmlands in most part (except Yunnan) may be less vulnerable as reservoirs may remain to store the same amount of water.		
	Water quality may be affected as there may be less water supply to flush out the pollution during the longer and dryer dry season		Many species might be able to migrate providing that continuous, relatively undisturbed, matural ecosystems are available	Some of the very lowland may have to be abandoned as the flood level and duration may be too long for any crops to survive or be productive.		
	Water demand would increase steadily while climate change is expected to lead to a decrease in water availability esp. in longer dry season		Changes in the timing of seasonal events during the yearly cycle would have strong negative impacts for many species, esp. migratory ones.			
	Dam constructions will out additional stress on wetland ecosystems by increasing habitat fragmentation		Species with narrow tolerance to environmental variability would be most vulnerable to change and most threatened by climate change.			
	Pressure to increase water storage capacity will increase					
	Northern and Eastern Highlands: Least suffered as the water supply from rainfall in terms of seasonally and overall amount will be more or less unchanged, yet there will be slightly less rain in dry season and slightly more rain during the last few months of the rainy season but that should not much affect largely non-irrigated areas.					
AIACC Regional Study AS07		Chance of landslide may increase as the rain in rainy season is likely to be heavier				
Hoanh, et al	Water shortages in Thailand may be accelerated through climate change: level of irrigation development if the NE Thailand region as well as Chao Phraya Basin in Thailand has resulted in a lack of water during the dry season. Additional storages are unlikely because of poor economics and poor environmental outcomes.	In megacities and large urban areas, high temperatures and heat waves also occur. These phenomena are exacerbated by the urban heat-island effect and air pollution		Frequent floods, droughts, cyclones, sea level rise, higher temperature will have significant effects on agriculture in many parts of the MRB: damage life and property and severly reduce agricultural production.		
AIACC Working Paper No. 40 October 2006 "Climate Risks and Rice Farming in the Lower Mekong River Countries"				Farmers' Observations of Climate: a. Increasing variability in dates of onset and end of rainy season b. Changes in wind direction pattern (varies throughout the season) c. Changes in rainfall distribution pattern throughout the season d. Increase in thunderstorm activity Farmers' Concerns about Climate: a. Midseason dry spell particularly after sowing rice seeds or transplanting seedlings • Limited irrigation area in LMB o Farmers rely mainly on natural rainfall for farming activity o Timing of farming practices depend greatly on rainfall distribution in the year b. Flood particularly near the end of crop cycle before harvesting • Increasing flood risk due to CC raised high concerns among farmers		
AICC Report, Anond Snidvongs of SEA START RC				Lao PDR, Savannakhet Province: Future climate condition may have slightly negative impact on the rain-fed rice production in study site in which would be reduced by 10% under climate condition at CO_2 of 540ppm but will be back to almost the same as baseline condition under climate condition at CO_2 of 720ppm. Under 540ppm, over 80% of surveyed population is under low risk category, while approx. 10% is in moderate riskk and only slightly over 5% is in high risk categories. No substantial difference between situation under normal condition and extreme climate event situation.	Thailand, Ubonratchathani Province: Simulation result shows that CC has positive impact on rice productivity in the study area, showing a trend of an increase in yield of rice productivity as high as 10-15% in some areas under future climate condition. Approx. 1/3 of survey population is at a low risk to climate impact, while moderate risk group accounting for approx. 40-50% is the largest group. CC has favorable impact on rice cultivation but influence of extreme climate events can cause a large portion of population to be vulnerable where in this case, many from the moderate group moved to high risk group.	Vietnam: Winter spring crop will get slight impact from CC as the yield will increase slightly from baseline under year climate conditions at CO_2 of 540ppm but will drop slightly under 720ppm CO_2 concentrations. Summer-autumn crop tends to be severely impacted by CC as simulation shows significant decline in crop productivity by approx. 8-12% under 540ppm CO_2 concentration and would sharply drop to almost 50% in some areas under 720ppm concentrations.

Special Report on Emission Scenarios	Storylines
SRES A1	A future world of very rapid economic growth, low population growth and rapid introduction of new and more efficient technology. Major underlying themes are economic and cultural convergence and capacity building, with a substantial reduction in regional differences in per capita income. In this world, people pursue personal wealth rather than environmental quality.
SRES A2	A differentiated world; Underlying theme is that of strengthening regional cultural identities, with an emphasis on family values and local traditions, high population growth, and less concern for rapid economic development.
SRES B1	A convergent world with rapid change in economic structures, "dematerialization" and introduction of clean technologies. The emphasis is on global solutions to environmental and social sustainability, including concerted efforts for rapid technology development, dematerialization of the economy and improving equity.
SRES B2	A world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a heterogeneous world with less rapid, and more diverse technological change but a strong emphasis on community initiative and social innovation to find local, rather than global solutions.

Author	Title	Date Published	Methodology	Comment	Document Website
Solomon, et al.	IPCC, 2007: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change	2007	AOGCMs (Atmosphere-Ocean General Circulation Models) and MMD (Multi-Model Data Set)	The most recent IPCC Report (2007) on climate change. Most of the literature gathered for the project are based on 2001 IPCC Report scenarios.	http://ipcc-wg1.ucar.edu/wg1/wg1-report.html (accessed 25-Aug-07)
Suppakorn Chinvanno	Information for Sustainable Development in Light of Climate Change in Mekong River Basin	Published for a conference titled "CLOSING GAPS IN THE DIGITAL DIVIDE: REGIONAL CONFERENCE ON DIGITAL GMS" held on February 26-28, 2003 in Bangkok	700ppm CO2	Showed various scenarios on principal landforms of the Mekong River Basin. General finding is the shift in seasonal pattern and increase in temperature.	http://203.159.5.16/digital_gms/Proceedings/A77_SUPPAKORN_CHINAVANNO.pdf (accessed 15-AUG-07)
Arora and Boer	The Effects of Simulated Climate Change on the Hydrology of Major River Basins	no date indicated (could be 1999 or 2000)	31 years of daily runoff data from the control simulation and from years 2070-2100 of transient climate change simulation forced with projected GHG concentrations and aerosol loading with CCCma's coupled general circulation model are used	Only literature that indicated a decreased river discharge and decreased flood magnitude. Could be due to methodology used.	
AIACC Regional Study AS07	Southeast Asia Regional Vulnerability to Changing Water Resource and Extreme Hydrological Events due to Climate Change	mid-year 2003	2xCO2 GHG scenario	No descriptions on scenario maps of temperature and rainfall	
Aerts et al (2006)	Sensitivity of Global River Discharges under Holocene and Future Climate Conditions	3-Oct-06	Comparative analysis of global river basins using atmosphere-ocean-vegetation model ECBilt-CLIO-VECODE to perform a transient simulation of the last 9000 years and SRES A2, gradual increase in CO2 between 1750 and 2100AD as well as hydrological model STREAM.	Study concluded that future climate change due to increased GHG concentrations will have profound effect (higher discharge) on global river basins compared to effects of natural long-term Holocene climatic variability dominated by orbital forcing.	
IWMI (as part of ADAPT project which analyzed 7 of the world's rivers)	The Mekong Basin in Southeast Asia: Climate Change and Challenges	Mar-03	SLURP (Semi-Distributed Land Use-based Runoff Processes) model; Without changes to land use and no adaptation measures	Most of the data are adapted from IPCC and ADAPT	
Jeffrey Jacobs	Adjusting to Climate Change in the Lower Mekong	1996	comparison of 3 global climate models which simulated doubling of CO2 from preindustrial times to year 2030	A good article for understanding institutional framework in MRB for climate change adaptation strategies but not much data on climate change scenarios and impacts	
Hoanh, et al. (ADAPT Project)	Water, Climate, Food, and Environment in the Mekong Basin in Southeast Asia	Jun-03	SRES A2 and B2; comparison of climate data during 1961-90 in different data sets; SWAP and SLURP models	Provided a good overview of the current state of the Mekong River Basin. Also showed detailed projected scenarios not just on climate but also on population and food under different adaptation strategies	
Water Utilization Program/Environment Program (Mekong River Commission)	Integrated Basin Flow Management Specialist Report (IBFM 3): Using DSF to Analyze Impacts of Climate Change on Mekong River	15-Dec-06	IPCC data are downscaled to sub-basins and adjusted and tested with SWAT model then the DSF model and data are revised and incorporated into BDP scenarios	The process of climate change study is currently in its second year of three. Study will be finished in 2008.	
SEA START RC	Trends of Climate Change in Lower Mekong River Basin	no date indicated on website	Study was based on high-resolution regional climate scenario which was simulated for SEA region using climate modeling technique. Used the Conformal Cubic Atmospheric Model (CCAM) and the simulation scenario of increasing CO2 concentration from 360ppm to 540ppm and 720ppm.	Scenario simulation was conducted for whole SEA region and southern part of China for 10 years at each atmospheric concentration level. However, analysis and adjusting process was focused on LMB in Lao PDR, Vietnam and Thailand only due to limited availability of observed climate data.	http://research.start.or.th/climate/index.php?option=com_content&task=view&id=20&Itemid=28
Suppakorn Chinvanno, et al.	AIACC Working Paper No. 40 "Climate Risks and Rice Farming in the Lower Mekong River Countries"	Oct-06	Modeling simulations from Conformal Cubic Atmospheric Model (CCAM) with 3 levels of atmospheric concentrations of CO2: 360ppm (baseline), 540ppm and 720 ppm. Also did household surveys and focus group studies to assess adaptation strategies of farmers to climate risks.	A good article providing current adaptation measures and practices of farmers in selected study sites of LMB to climate risks. Also analyzed these measures in household or farm, community and national levels, and provided further recommendations on climate change adaptation at these levels.	
Anond Snidvongs (SEA START RC)	Vulnerability to Climate Change Related to Water Resource Changes and Extreme Hydrological Events in Southeast Asia	2006	CCAM regional climate modeling technique to study changes in climate pattern. VIC (Variable Infiltration Capacity) model to study impacts of CC on hydrological regime. DSSAT 4.0 (Decision Support System for Agro Technology Transfers) as crop model to study impact of CC on rain-fed agriculture in LMB. Field survey approach in assessment of vulnerability and adaptation of rain-fed farmers to CC	Study showed that vulnerability is a site-specific condition, which depends upon the degree of climate impact and socio-economic condition as well as physical condition of each site. The profile of risk to climate change impact would differ from community to community.	
Cruz, et al.	Climate Change 2007: Impacts, Adaptation and Vulnerability: Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change	2007	AOGCMs (Atmosphere-Ocean General Circulation Models)	Focused on impacts of climate change in economic and social aspects of the region based on the projected assumptions on climate change.	
Preston, et al. of CSIRO Marine and Atmospheric Research	Climate Change in the Asia/Pacific Region: A Consultancy Report Prepared for the Climate Change and Development Roundtable	11-Oct-06	23 Climate Models were available for generating climate change projections for the Asia/Pacific region. 16 of these models were selected after applying reliability criteria. Also used Pattern Scaling Techniques to develop annual and seasonal "patterns of change" per degree of global warming for each of the 16 climate models.	Aside from giving projected changes as based on consistency and accuracy of predictions of the various climate models, the article also pointed out degree of uncertainties in some of these projected scenarios.	
Asian Disaster Preparedness Center (ADPC) Bangkok	Climate Change and Development in Vietnam: Agriculture and Adaptation for the Mekong Delta Region	Dec-03	Source of climate scenarios are taken from NOCCOP (National Office for Climate Change and Ozone Protection - Vietnam) 2002	Gave an overview of future climate and impacts of climate change in Vietnam and options for adaptation measures on Vietnam's agriculture	
P.T. Adamson (MRC)	An Evaluation of Landuse and Climate Change on the Recent Historical Regime of the Mekong	Dec-06	Potential changes to hydrological regime of the Mekong is analyzed by looking at potential impacts of landuse change (regional deforestation since 1960s) and hydro-meteorological data (regional rainfall data 1960-2005) of the Mekong at Vientiane and Kratie.	Found no significant manifestation of human-induced change within IBFM context of the Mekong. Also found no significant evidence within observed data to support claims that climate change impacts are already manifest in the region.	
Hoanh, et al.	Will We Produce Sufficient Food under Climate Change? Mekong Basin (South-east Asia)	A chapter from "Climate Change in Contrasting River Basins."(eds Aerts and Droogers). 2004	SRES A2 and B2; comparison of climate data during 1961-90 in different data sets; SWAP and SLURP models	Same data findings with earlier article by Hoanh et al on Mekong Basin (2003). Purported that crop intensification will be the trend of agricultural development in MRB. With or without climate change and considering different adaptation strategies, higher irrigation requirements will likely cause water shortage at upstream sub-basins.	