Mekong River Commission

Draft Working Paper:

Reference Scenario for the Council Study

This working paper introduces the terms “reference scenario” and “reference period” to signify an explicit new and common understanding of their intended use in the Council Study. Reference scenario is simply one of the development scenarios selected as a reference or a basis for comparing modeled conditions of other development scenarios. The reference period refers to the common hydrologic time period or sequence used to run the models to allow “apple-to-apple” comparisons of modeled conditions between the reference scenario and the development scenario.

For the Council Study, the following are proposed:

- Reference Development Scenario: Represent physical/socio-economic conditions (i.e., levels of development) in 2007 but without the mainstream dams in China*
- Reference Hydrological Period: 1985 – 2008
- Development Scenarios: Pre-development, 2000, 2007, 2020, and 2040

This working paper describes the approach for comparing modeled flow, sediment, and water quality conditions between scenarios, the extension of the analysis to assessing associated biological resources and socio-economic impacts, and their linkage to the Council Study main report deliverables such as the cumulative assessment and thematic assessment reports.

*A reference scenario is chosen to make the scenario comparisons more manageable. However, an alternative is not to select a reference scenario and instead compare scenarios from each other as needed during the analysis to determine relative impacts.

25 September 2015

CONTENTS AMENDMENT RECORD

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Signed
1	0	Initial Draft	14/09/2015	Robert[1]/Henry/Modelling Team
	1	Added Preamble on Key Points Agreed by MCs During 5th RTWG Meeting and How Working Paper Specifically Addresses Them	25/09/2015	Henry/Modelling Team

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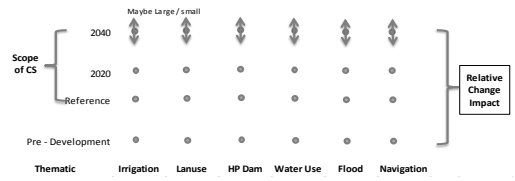
1 Preamble

This working paper presents holistically the scenario assessment approach including key terms such as reference scenario and reference period based on the concept that was agreed by the Member Countries during their private meeting at the 5th RTWG Meeting. As illustrated in Attachment A, the concept contains five key elements. The following table is prepared to specifically explain how this working paper addressed each of the 5 key elements.

Key Elements of the Concept from the Private Meeting During the 5th RTWG Meeting	**Explanation on How This Working Paper Addressed the Key Elements**
Check rainfall and evaporation for long-term	The need to check rainfall and evaporation for long-term is mentioned in Footnote 4 (page 5 of the working paper) which states that "to enhance the comparative process, it is important to analyse whether the 1985-2008 rainfall and evaporation series used for the reference period are unbiased estimates of the longer term record". As mentioned in Section 3.2, the use of a common hydrological sequence is necessary to generate comparison statistics over the range of hydrologic conditions in the basin and allow comparisons. IBFM Phase 1 project in 2004 investigated the representativeness of the 1985-2000 flow data. The conclusion of the study was that the 16-year flow data can be considered representative of the long-term record. In addition, CCAI has conducted similar work more recently. A similar analysis on flow, rainfall and evaporation can be conducted for the 24 year period (1985-2008) if needed.
Six thematic areas can start on different point and rate of progress - Picking a given time and fixing scenario is based on initial state - Choose a reference data set which has relative basis and good coverage	The reference scenario is proposed to make the scenario comparisons more manageable. It is also noted in the summary page of the working paper that other scenario comparisons can be conducted. Therefore, if a certain thematic team prefers to use 2000 as the reference state/scenario for determining impacts, the approach offers the flexibility to do that. If another thematic team prefers to use significantly pre-development scenario as a reference state, that

	can be done also. A scenario without the Chinese mainstream dams was also included in the working paper to provide more flexibility. The significantly pre-development scenario is assumed at this time as a no-development scenario (i.e., no infrastructure in the DSF model). However, if determined later on, it can be associated with a specific year (i.e., 1960, 1900, etc.).
From reference scenario, can forecast and hindcast to generate impact of change.	This is addressed as per approach of the scenario comparisons. The selected reference scenario can be compared against a scenario in the future (forecast) and scenario in the past (backcast). Page 5 of the working paper also states that statistics (statistical measures and other indicators) will be used for scenario comparison. These statistics will be identified later on in consultation with MCs after agreement is reached on the working paper
Sub-scenarios evaluated only on 2040 to assess uncertainty  	Addressed in pages 10-11 under the section Note on Thematic Sub-Scenarios
Creating estimates (e.g., 1960) can be based on temporal estimates	The working paper provides the flexibility to address this. As noted earlier, the pre-development scenario can be specified to represent either no development, 1960, or any other selected year in the past to determine modelled condition representing natural flow and predevelopment conditions.

2 Objective

The objectives of this working paper are the following:

- Clarify the difference between scenarios under the Council Study modelling methodology and the BDP approach to ensure common understanding of the Member Countries
- Describe how modelling scenarios for the Council Study are developed
- Describe how modelling scenarios for the Council Study are compared and utilized to produce information on the distribution of positive and negative impacts, benefits, costs, and risks across the basin.

3 Scenarios under the Council Study

The Council Study aims to assess the impacts (positive and negative) of past, ongoing and planned water resources development in the Mekong River Basin in order to produce information on the distribution of the impacts, benefits, costs, and risks across the basin. Clearly the determination of impacts and associated changes in benefits, costs and risks is somewhat subjective, and relates to how a comparison of two sets of information is interpreted. The important issue for the modelling team is that the basis of comparison should be sound from a technical perspective.

A scenario consists of two aspects:

1) A time period over which hydrological drivers (rainfall, evaporation, etc.) are suitable as the basis for comparison (i.e. stationary and representative)
2) States of development that describe the physical/socio-economic status including the environment, land use, water use and infrastructure. These basin states may represent conditions in the past, present or future but none of them represent a single year in time as a historical fact.

The assessment of the impacts, costs, benefits, and risks is based on the comparison of modeled scenarios, and therefore scenario modelling is not an attempt to predict the future or past, rather each scenario is only relevant when compared to another scenario.

The term “Baseline” is a terminology used in the BDP analysis as it makes projections of the basin state into the future and compares them against the physical (infrastructure) condition in 2000 and socio-economic conditions in 2008/2009. While there are similarities in the modelling approach between BDP and the Council Study, the BDP development scenarios are mostly integrated and cumulative in the sense that they do not attempt to tease out the detail of how an impact (positive of negative) is generated.

Cumulative impacts at any one location are made up of both potentially positive and negative impacts from the individual elements (i.e. one may cancel another one out) and so to understand this detail, the Council study is designed to provide an estimate of the relative contribution of each of the modelled thematic areas to cumulative impacts across the LMB. The Council Study approach is therefore different from BDP in that the focus is on defining the relative positive and negative contribution by the thematic areas on total impact through statistical comparison of two scenarios. The 5th RTWG Briefing Notes Package defines the 24 model scenarios which serve as the basis for the analysis.

3.1 Reference Period

During the 5th RTWG Meeting, the Member Countries agreed to use the term “reference period” to describe the time period over the analysis is undertaken instead of the earlier BDP nomenclature “baseline period”.to signify an explicit new understanding of the term and its use in the Council Study.

3.2 Reference Scenario

- As noted earlier, the assessment of the impacts, costs, benefits, and risks is based on the comparison of modeled scenarios. This requires a definition of which scenario is the "reference scenario" and which one is the "test scenario" so that relative impacts can be defined in a consistent manner. For the Council Study, a reference scenario represents an integrated set of levels of development and management in the 6 thematic areas.
- The conditions associated with the reference scenarios will be modeled using the Council Study models[2]
- The modeled conditions associated with the reference scenario will be used as a basis for comparing the modeled conditions of other scenarios
- The choice of a reference scenario does not imply that changes from this condition are 'good' or 'bad' – the reference scenario is selected only as a basis of comparison.
- Scenarios other than the reference scenario, represent varying sets of levels of development and management in the 6 thematic areas, hence, they may also be referred to as "development scenarios". Again, development may be more or less than the reference condition.
- The conditions associated with the reference scenario and the other development scenarios are modeled over the common "reference hydrological period which has been selected to be from1985 – 2008[3]. It should be noted that the level of development for each thematic area will remain constant throughout the reference hydrological period.
- All other model parameters that are not directly influenced by the levels of development will be held constant from one scenario simulation to another. The values for these model parameters are based on the calibrated model.

Moreover, the following additional clarifications are provided about the modeling approach, and what the model results represent and their intended use in the Council Study.

- The use of a common hydrological sequence (i.e., common reference hydrological period) is necessary to generate comparison statistics over the range of hydrologic conditions in the basin and allow 'apple-to-apple comparisons[4]. It does not evaluate changes in the basin over this period.
- The year-to-year changes in modeled conditions over the hydrologic period are not important. Statistical tendencies or measures, and other indicators of these changes

[2] Refers to DSF supplemented by WUP-FIN and eWater Source to simulate flow, sediment, and water quality

[3] The hydrologic period 1985-2008 was agreed in principle by MCs during the Small Technical Work Group Meeting on April 2015 pending availability of additional climate data to extend this hydrologic period to 2011/2012. During the 11th TACT Meeting in August 2015, the selected hydrological period is confirmed to be from 1985-2008.

[4] To enhance the comparative process, it is important to analyze whether the 1985-2008 rainfall and evaporation series used for the reference period are unbiased estimates of the longer term record. This analysis is in accordance with section 3.4 of the Council Study Inception Report which stated the importance of considering long term temporal stationarity of the selected reference period.

will be used to facilitate the comparison of modeled conditions between scenarios. For example, these indicators will include modeled hydraulic, hydrologic, sediment, and water quality parameters that have been already identified as driving indicators for ecosystem indicators for the biological resource assessment

- The modeled conditions do not necessarily represent actual conditions in the past or future predictions. They simply represent modeled conditions associated with a set of plausible levels of developments in the thematic areas over a given hydrologic sequence. To be plausible, the levels of development represent agreed levels of development in each of the thematic areas.
- The Council Study is not a predictor of future conditions at any one time (i.e. 2040) as there are other factors that need to be adequately accounted for including predicting future climatic and hydrologic drivers and accounting for the influence of exogenous developments (e.g., outside the water sector) among many other things.

4 Proposed Reference Development Scenario

Based on the definition of reference development scenario in the previous section, the choice of reference scenario involves the choice of what level of development and management will be used as a reference for comparing other scenarios that represent different levels of development. As noted earlier, these other scenarios represent anticipated levels of developments in the future or snapshots of levels of developments in the past.

During the 4th RTWG Meeting, the Member Countries agreed to assess the following development scenarios:

- Early Development using estimates of physical/socio-economic condition as of 2007
- Definite Future Scenario using a projected physical/socio-economic condition as of 2020
- Planned Development Scenario using a projected physical/socio-economic condition as of 2040

In addition, during the 5th RTWG Meeting, the Member Countries have also expressed interest in assessing the impact of development estimates of physical/socio-economic condition in 2000, particularly in relation to the impact of Chinese dams as compared to the physical/socio-economic condition in 2007. Other combinations were also discussed, for example a 'pre-development' scenario which may look at the physical/socio-economic condition at some point in the last century including for instance for a situation before massive agricultural expansion. The modelling approach described in this paper allows for any combination of physical/socio-economic conditions as long as they can be represented by the modelling tools.

While any of the abovementioned development scenarios representing the past (e.g., pre-development, Year 2000, or Year 2007) can be used as a reference or basis for comparison, it is proposed that the physical/socio-economic condition in Year 2007 but without the mainstream dams in China is used to represent the reference scenario (hereinafter referred to as reference scenario 2007) for the following reasons:

- The reference scenario 2007 can be modeled sooner than the others because of the following:
    - the Council Study Thematic Teams have been collecting infrastructure and water use data corresponding to levels of development in 2007 for the six thematic areas
    - The most recent version of DSF model already incorporates 2007 infrastructure data
- Year 2007 appears to be a convenient "marker" to separate the analysis between scenarios that involve planned levels of developments in the future (e.g., 2020 and 2040); and scenarios that involve levels of development in the past (e.g., 2000, or if

necessary, a scenario with all developments taken out from the model to represent pre-development natural conditions[5])

Year 2000 is less preferred to be the reference scenario because of lack of data at this time especially for the agriculture and land use change, navigation, and flood protection and floodplain infrastructure thematic areas. The thematic teams will have to be instructed to reprioritize their ongoing data collection efforts to focus on Year 2000 including updating the data for hydropower, irrigation, and domestic and industrial water use that are already available from BDP2.

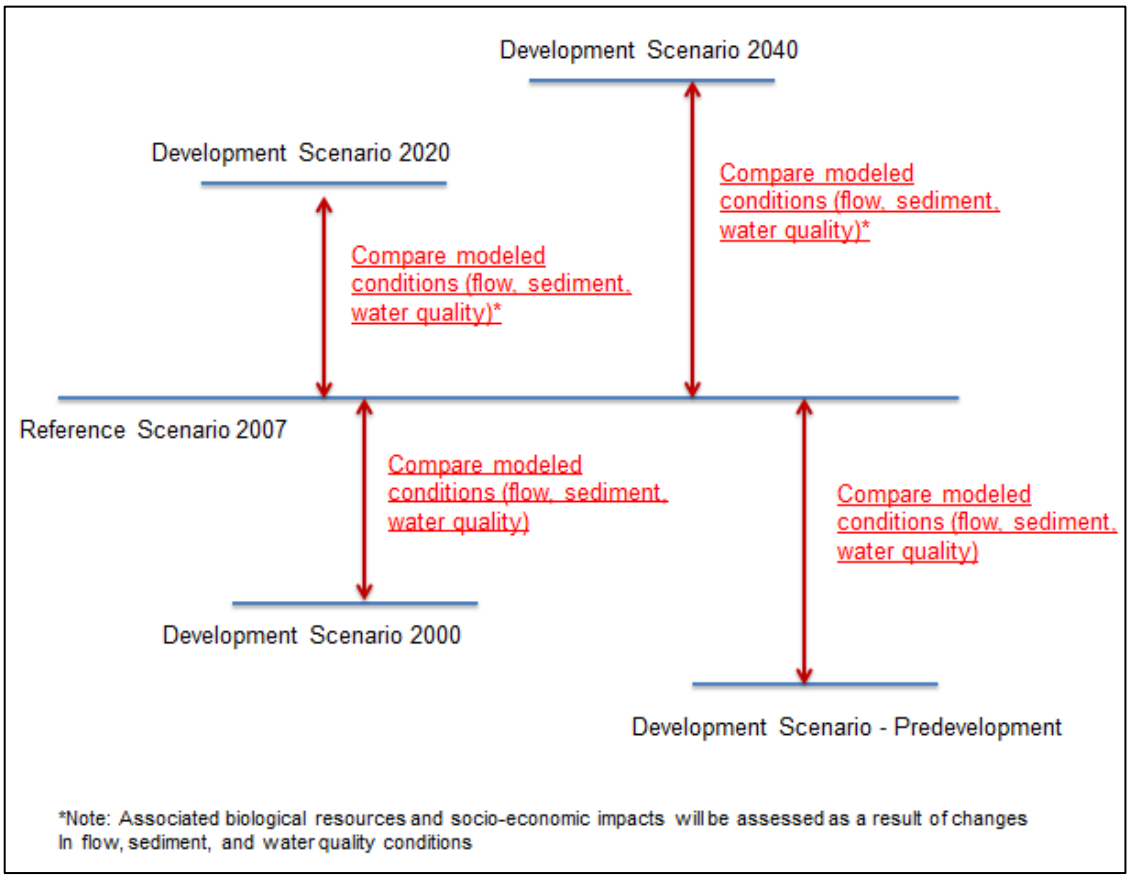
Pre-development scenario is also less preferred because of the uncertainty in the model's ability to simulate natural conditions other than perhaps flow under the pre-development scenario.

[5] The model may not necessarily reproduce (or hindcast) accurately pre-development natural conditions because pre-development basin characteristics are significantly different from the calibrated model conditions. The model may reasonably reproduce pre-development natural flow conditions but most-likely not sediment and water quality.

5 Use of Proposed Reference Scenario for Scenario Assessments

The figure below illustrates the development scenarios that will be modeled and compared with the reference scenario. As noted earlier, the development scenarios represent planned levels of developments in the future and snapshots of levels of developments in the past. The use of reference scenario allows the analysis of change in modeled conditions through the following paired scenario comparisons.

- Between development scenario 2020 and reference scenario 2007
- Between development scenario 2040 and reference scenario 2007
- Between development scenario (or snapshot) in 2000 and reference scenario 2007
- Between pre-development natural conditions scenario and reference scenario 2007
- Between development scenario 2007 (with mainstream dam in China) and reference scenario 2007



The change in modeled conditions refers to changes in modeled flow, sediment, and water quality between the paired scenarios. These changes will be used as the basis for assessing biological resources (ecosystem) and socio-economic impacts through the use of assessment methodologies that are currently being developed for the Lower Mekong Basin (LMB) under the Council Study[6]. It should be noted that the assessed impacts from these

[6] Assessment of biological resource impacts as a result of changes in flow, sediment, and water quality will use DRIFT-DSS that is currently being developed for LMB. Corresponding socio-economic

paired scenarios represent the cumulative impacts as a result of the combined changes in levels of developments in the six thematic areas.

The following are the key steps involved in the scenario assessments:

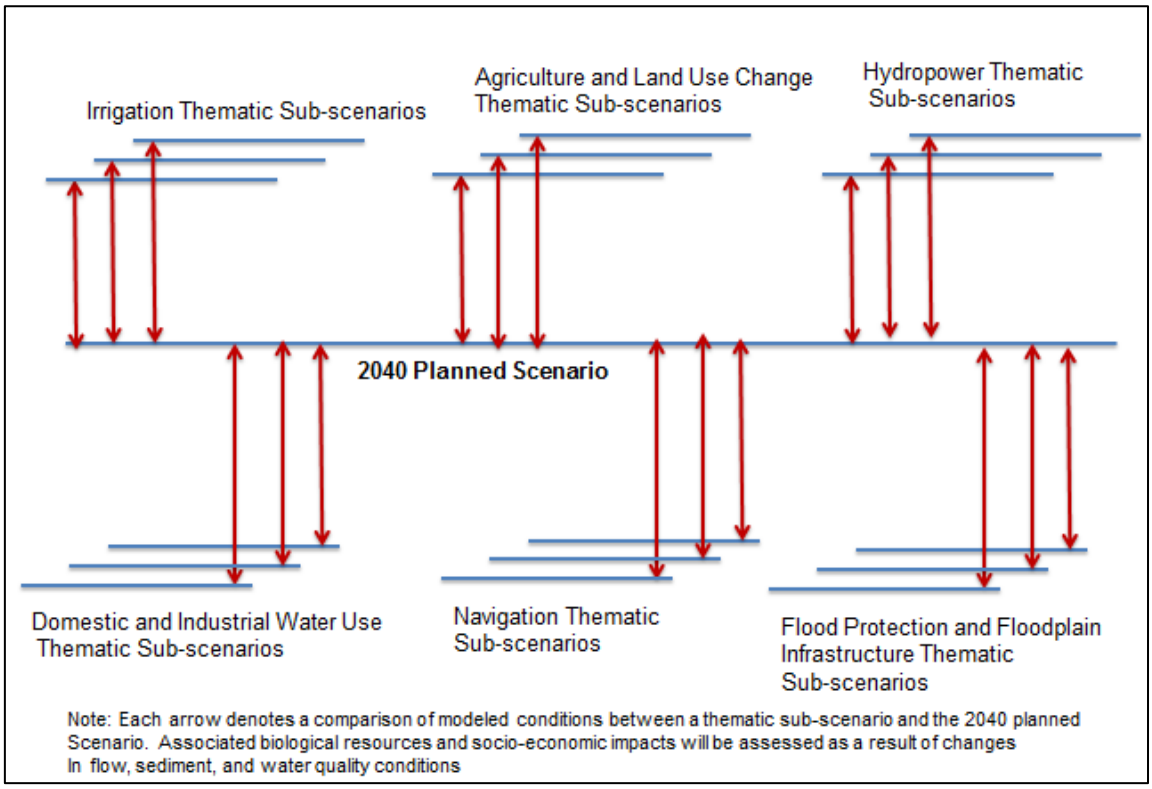
- Using the calibrated models of DSF, WUP-FIN, and eWater Source, simulate the flow, sediment and water quality conditions for the reference scenario
- Update the calibrated models of DSF, WUP-FIN, and eWater Source to reflect changes in levels of developments and simulate the follow, sediment and water quality conditions for the development scenarios (physical and socio-economic conditions in 2007, 2020, 2000, and pre-development). Recalibrating the models is not necessary and would in fact invalidate the basis of comparison by bringing in additional variables).
- Compare the simulated (modeled) conditions between the paired scenarios (reference scenario vs. development scenario) using statistical measures and indicators to determine modeled impacts (i.e., changes in modeled conditions)
- Use the modeled changes in flow, sediment, and water quality as input to to determine corresponding biological resources, and socio-economic impacts. The biological, resources and socio-economic assessments will be performed only for the 2020 and 2040 development scenarios. The assessment for pre-development and 2000 will be focused on changes in flow, sediment, and water quality.

Note on Thematic Sub-scenarios

In addition to the main development scenarios mentioned above (pre-development, 2000, 2020, and 2040), thematic sub-scenarios are being formulated for each thematic area (i.e., maximum of three sub-scenarios per thematic area). These thematic sub-scenarios represent plausible thematic-specific deviations from the 2040 planned development scenario[7]. As illustrated in the figure below, the assessment of these thematic sub-scenarios involves comparing the modeled conditions of the thematic sub-scenarios against the modeled conditions of the 2040 planned development scenario and not against the reference scenario. This approach is similar to performing a sensitivity analysis of relative impacts to plausible changes in the levels of developments within a specific thematic area. The results of this sensitivity analysis is crucial to improving the understanding of both the positive and negative impacts of a particular development stressor and in using that improved knowledge to explore infrastructure and management measures within the thematic area to enhance positive impacts and minimize negative impacts. It should be noted that it is not the objective of the thematic sub-scenarios to compare relative impacts between thematic areas.

impacts will be assessed using a socio-economic assessment methodology that will be developed during a scoping mission on 14-28 September 2015

[7] Concept of thematic sub-scenarios have been discussed during the 5th RTWG Meeting and are currently being formulated by the thematic teams in direct coordination with their national Programme counterparts



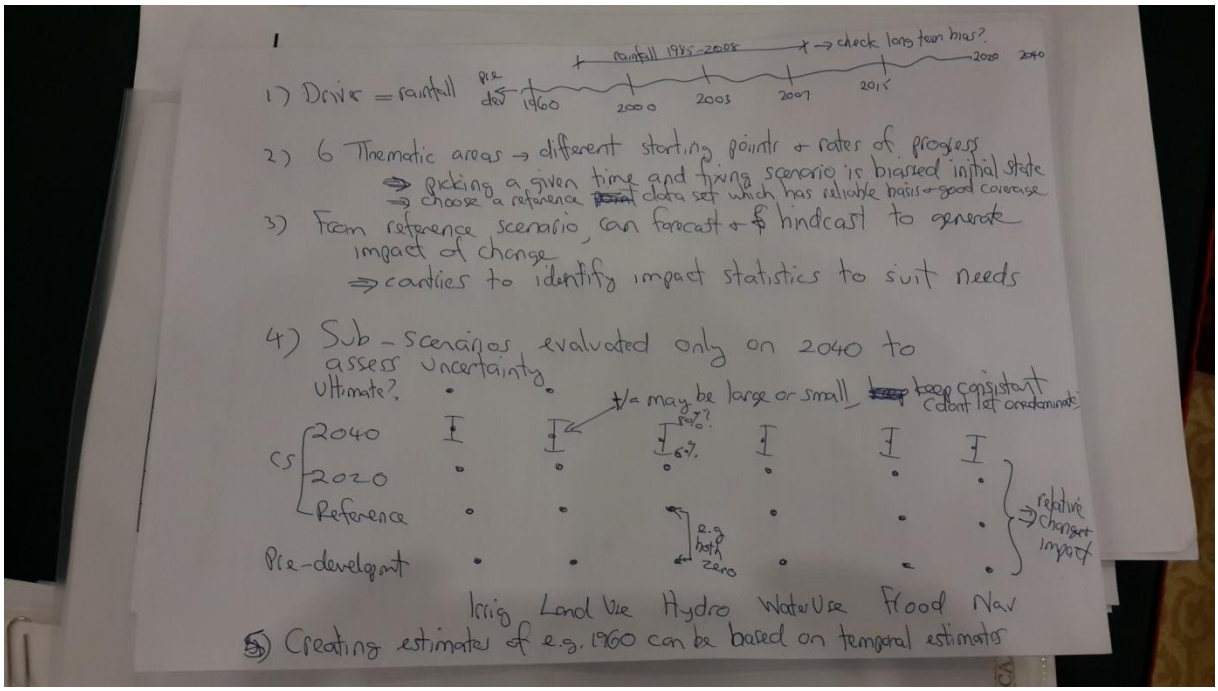
Note on Cumulative and Thematic Reports

The Council Study's main report deliverables include one cumulative assessment report, and six separate thematic reports (one for each thematic area). The impact assessment chapter of these reports will be primarily based on the results of the scenario assessments. The table below illustrates what scenario assessments will be used for which reports.

Report Deliverable	Scenario Assessment
Cumulative Assessment	Pre-development, 2000, 2020, 2040 as compared against reference scenario (2007) The assessment results of the thematic sub-scenarios (see below) can also be used to supplement the assessment results for the main development scenarios in identifying infrastructure and management measures that will enhance positive impacts and minimizing negative impacts
Thematic Report on Irrigation	Irrigation Thematic Sub-scenarios as compared against 2040 planned scenario
Thematic Report on Agriculture and Land Use Change	Agriculture and Land Use Change Thematic Sub-scenarios as compared against 2040 planned scenario
Thematic Report on Domestic and Industrial Water Use	Domestic and Industrial Water Use Thematic Sub-scenarios as compared against 2040 planned scenario
Thematic Report on Hydropower	Hydropower Thematic Sub-scenarios as compared against 2040 planned scenario

Thematic Report on Navigation	Navigation Thematic Sub-scenarios as compared against 2040 planned scenario
Thematic Report on Flood Protection and Floodplain Infrastructure	Flood Protection and Floodplain Infrastructure Thematic Sub-scenarios as compared against 2040 planned scenario

Attachment


1) Drivr = rainfall
rainfall 1985-2008
check long term bias?
Pre dev
1960
2000
2003
2007
2015
2020
2040
2) 6 Thematic areas → different starting points & rates of progress
⇒ picking a given time and fixing scenario is biassed initial state
⇒ choose a reference data set which has reliable basis & good coverage
3) From reference scenario, can forecast & hindcast to generate impact of change
⇒ cantles to identify impact statistics to suit needs
4) Sub-scenarios evaluated only on 2040 to assess uncertainty
Ultimate?
+/- may be large or small
keep consistent
CS
2040
2020
Reference
Pre-developmt
e.g. back to zero
relative change = impact
Irrig Land Use Hydro Water Use Flood Nav
5) Creating estimates of e.g. 1960 can be based on temporal estimates