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Discussions

Interactive comment on "A century scale human-induced hydrological and ecological changes of wetlands of two large river basins in Australia (Murray) and China (Yangtze): development of an adaptive water resource management framework" *by* G. R. Kattel et al.

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Reviewer #1 comments and answers General comments "…the transition from a fairly comprehensive discussion of eco-hydrology to adaptive water resource management (effectively socio-hydrology) to be very abrupt and not well supported." Answer: In the revised manuscript the following statements has been added in Section 1.0 to resolve this issue (also please see Section 6.2 below). Section 1.0 "…………Understanding

the linkage between eco-hydrology and adaptive water resource management or 'socio-hydrology' is increasingly important in large river basins, since interaction between people and water is fundamental (Nilsson and Berggrern, 2000). However, the use of palaeoecology (subfossil cladocerans) is rarely examined in rapidly changing environments nor is its role in socio-hydrology. A participatory approach of water resource management has been found to be successful in many regulated environments (Falkenmark, 2004). Such an approach is sustainable in nature and has increased levels of integration between natural and social scientists, land and water users, land and water managers, planners and policy makers across spatial scales (Macleod et al., 2007). This type of integrated platform is crucial for learning and exchange of knowledge among stakeholders for successful management outcomes (Pahl-Wostl, 2009). Based on evidence from subfossil cladocerans, we have proposed an adaptive water resource management framework for the Murray and Yangtze River wetlands."….. "The framework presented comes across as being somewhat simplistic and superficial, without sufficient grounding in the literature (given the framework components proposed have little connection to the body of the manuscript)." " For the last section to form a useful contribution I believe it needs to be substantially enhanced (there is much in recent socio-hydrology and adaptive management literature to augment with). Otherwise I would suggest the authors perhaps de-emphasize this section (e.g. excluding it from the title) and possibly restructure it as either 'implications of the results' or 'possible avenues for future research' rather than a framework that is capable of guiding water management" Answer: We agree that these comments are highly genuine. But what we would like to clarify that we have been trying to use this framework in two large river basins of Australia and China very first time by linking eco-hydrology and socio-hydrology based on the historical records from the wetlands of Murray and Yangtze rivers. Adding the following statements in the revised manuscript Section 6.2 and 6.3 would address the question. Section 6.2 "……The alternative stable states phenomena in shallow lakes and wetlands have been widely viewed as indicative of changes to resilience of ecosystems (Scheffer and Jeppesen, 2007). Such phenomena have shown the condition of wetlands to vary from a relatively good water quality, vegetation-rich state to a poor, turbid water state, which is usually less desirable (Folke et al., 2004). Positive feedback associated with the condition of increased water quality, species richness and population dynamics of D. crassa in Kings Billabong prior to 1900 AD is characteristic of a resilient ecosystem (e.g. Suding et al., 2004). By contrast, an open water habitat, which may be characteristic of longer flood duration following regulation leading to negative feedback, which has less resilience and increased turbidity (e.g. Suding et al., 2004). Similarly, in Zhangdu and Liangzi Lakes, an increased abundance of smaller, mud-dwelling cladoceran species such as small Alona and Leydigia leydigi, as well as presence of other meso-eutrophic species, Chydorus and Bosmina following regulation is indicative of increased eutrophication (e.g. Hofmann, 1996) caused by alteration of flow regime and dehydration of wetlands. Chapin III (2000) argued that changing species diversity has functional consequences in ecosystem processes, which may be observed via impact on ecological traits. The components of species diversity expressing certain traits include the number of species present (species richness), their relative abundances (species evenness), the particular species present (species composition), the interactions among species (non-additive effects), and the temporal and spatial variation in these properties. The consequence to the environment as a result of cladoceran diversity change in Murray and Yangtze River wetlands is difficult to predict, but in the longer term, poor functioning of the ecosystem due to reduction in diversity in Kings Billabong is expected. In the Yangtze River wetlands, the dominant species richness trait, for instance abundance of small Alona group can also lead to poor ecosystem functioning (e.g. Chapin III, 2000). This evidence strongly reflects the reduction in resilience and the limited capacity of these wetlands supporting ecosystem services for human society in these increasingly regulated river basins. Further decline in eco-hydrological conditions including the water quality, water quantity, fishery resources, and recreational amenities, due to cumulative stressors can lead to the collapse of ecosystem services, in which case society will no longer be benefitted (e.g. Falkenmark, 2003). The ecosystems of

both Murray and Yangtze rivers are affected largely by a range of drivers. The cumulative stressors of these wetlands are nutrient enrichments from agricultural catchments, heavy metal release from industries (mainly in Yangtze wetlands) and climate change (flooding and drought episodes). Increased nitrogen deposition has been reported to have a greater effect on diversity and ecosystem functioning of wetlands leading to collapse of ecosystems (Hooper et al., 2012). The ecological collapse may lead to crises, with conflicting demands placed on natural resources and increasingly poor public health of the local community (Kattel et al., 2013). The participatory approach of river basin management can help increase resilience of wetland ecosystems and goods and services to society (Vörösmarty et al., 2010). Joint action by various stakeholders including ecologists, resource managers and decision makers can be useful to achieve management goals for natural resources (Biswas, 2004; Carpenter et al., 2009, Liu et al., 2014). Such an adaptive management approach for water resources is increasingly appropriate for maintaining ecosystem services of large river basins (e.g. Richter et al., 2003). Section 6.3 “Water problems in large river basins are increasingly interconnected with multi-sector developments such as agriculture, energy, industry, transportation and communication. Several authors (Walker et al., 1995; Kingsford et al., 2000; Fu et al., 2003) suggest that maintaining ecosystem health of wetlands of large river basins requires a new paradigm in water management. Today, the wetlands of both the Murray and Yangtze river basins have faced greater challenges from hydrological modification, water shortage and eutrophication than at any time previously (Yang et al., 2006; Shen, 2010; Gell and Reid, 2014). There are growing concerns about the uncertainties of climate change and socio-economic impacts on these river basins (Palmer et al., 2000). For example, due to a rapid decline in water quality, biodiversity and ecological characters of the lower Yangtze River, this region has already been declared as the ecosystem of “lost resilience” (Zhang et al., 2015). A comprehensive synthesis by Varis and Vakkilainen (2001) suggests that following the 1970s China’s environmental pressures have surpassed the carrying capacity of the ecosystem, resulting in greater challenges for water resource management in the Yangtze and many other river basins. Similarly, a rapidly declining trend of biological diversity and ecosystem states of the Murray River basin has also been widely reported following the 1950s (Kingsford et al., 2000). For example, more than 80% of wetlands in the Lower Murray River reaches (Australia) have undergone a significant decline in flow regimes and ecosystem health, due to rapid rates of sedimentation, turbidity and loss of macrophytes (e.g. Mosley et al., 2012; Gell and Reid, 2014). While the wetlands of both large river basins have experienced substantial loss of ecosystem services, river regulation during the 20th century, increasing demand for water, food, fibre, minerals, and energy in the 21 century has degraded conditions of these natural resources even further (e.g. Davis et al., 2015). Solutions for water issues are not possible without joint effort by the various stakeholders involved in understanding the complexity of water management in large river basins (e.g. Biswas, 2004). It has been envisaged that the current management framework needs to be revitalized to resolve growing issues of wetland management and maintenance of associated ecosystem services, including the quantity and quality of water in both river basins. Adoption of an Integrated Water Resource Management (IWRM) framework has been increasingly useful to resolve issues of quantity and quality of water worldwide. The IWRM promotes water management by maximizing relevant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems (Biswas, 2004). Over the past decades, IWRM approach has been constantly modified as per the societal needs of the water management. On this basis, we have proposed the development of an adaptive water resource management framework for wetlands of the two large, hydrologically-transformed river basins in Australia and China (Fig. 7). This consideration has been taken into account on the basis of eco-hydrological evolution of wetlands inferred by subfossil cladoceran assemblages and diversity (Figs. 4 & 5). These changes have been profoundly implicated by socio-economic developments in both river basins over the past century. The proposed adaptive water resource management framework (Fig. 7) is integrated and multi-disciplinary in nature, is intended to improve management and to accommodate change by learning from the outcomes of management (restoration) policies and

practices, as described by Holling, (1978) initially, and debated extensively after (Jakeman and Letcher, 2003; Macleod et al., 2007; Pahl-Wostl, 2007). Such management framework has previously been facilitated by dialogue between scientists, stakeholders and policy makers, and can be expected to result in highly positive outcomes in management (Falkenmark, 2004). In the framework (Fig. 7), we consider that both quantity and quality of water determines the conditions of the wetland ecosystems of the Murray and Yangtze Rivers. Prior to regulation these wetlands were maintained by sustainable flow regimes with improved water quality and reasonably good (at baseline condition) ecological health. The natural flood inundations maintained the amount of water, nutrients, carbon and salts in wetlands supporting biological diversity, ecosystem functioning and associated goods and services (Junk et al. 1989, Thorp and Delong 1994; Humphries et al. 1999; King et al. 2003). This evidence is also supported by various eco-hydrological models being developed and tested previously to measure flow regimes and ecosystems of the large river wetlands worldwide (Vannote et al. 1980; Naiman et al. 1987; Thoms and Sheldon, 2000). The use of palaeoecological approach in this study provides the 1950s as a benchmark of change in flow regime and ecosystem of the Murray and Yangtze River wetlands (Fig. 7). Following river regulation (post 1950s), both quantity and quality of water in the Murray and Yangtze river wetlands had significantly altered, reaching a critically low level of flow and ecosystem health by the 2000s (Fig. 7). The condition of and changes in flow regime in the Murry River basin was reported by Maheshwari et al. (1995), where the average monthly and annual flows were considerably lower than those of natural conditions prior to regulation. We argue that the 2000s was the critical level of threshold for quality and quantity of water in wetlands of both river basins, and all available restoration measures should be adopted to avoid further decline in conditions in these wetlands. In our adaptive water resource management framework (Fig. 7), we have proposed the role of three pillars: science, engineering and community engagement when restoring the degraded wetlands of these two large river basins of Australia and China. River regulation, including widespread infrastructure developments across these river basins, has consistently modified natural hydraulic residence time, leading to changes in diversity and associated ecosystem structure and function of wetlands. For example, construction of Hume Dam in 1930s in Murray River, and several large dams, including the Three Gorges Dam (TGD), since the 1950s in Yangtze River will have long-lasting effects on downstream flow regimes, and wetland ecosystem structure and function (Pittock and Finlayson, 2011; Wu et al., 2003). Whilst these infrastructures are already in place, strong scientific evidence including the understanding of alterations of historical ecology and hydrology is potentially powerful tool to unravel the benchmark of the eco-hydrologic conditions of the Murray and Yangtze River wetlands over time. The benchmark is potentially important for the development of predictive models in future wetland restoration programs (Bennion et al., 2011). Predictive models can identify early warning signals of regime shift and resilience changes in individual wetlands and lakes (Wang et al., 2012). Resource managers can target restoration measures on the basis of benchmark conditions and employ appropriate prediction models so that investment will not be wasted on restoration of wetlands that would not result in improved values. Zweig and Kitchens (2009) suggest that the predictive hydrologic models can be the foundation for restoration programs of degraded wetlands, since these models can successfully identify the hydrologic effects on the state of transitioning ecosystems. Secondly, innovative and environmentally-friendly infrastructure developments and operation have been proposed in water restoration programs worldwide and there is an increased demand of efficient infrastructure development for the Murray and Yangtze River basins (e.g. Fu et al., 2010). One of fundamental issues of the integrated water resource management program is to meet balanced water allocations between industry and environment (Poff et al., 2003; Biswas, 2004). Due to overwhelming industrial demand of water in recent decades, economists have developed efficient environmental water allocation schemes for various river basins including the Murray and Yangtze (e.g. Lee and Ancev, 2009; Jiang, 2009). The proposed adaptive water resource management framework (Fig. 7) highlights the role of institutional capacities and development of efficient water allocation infrastructures (e.g. Yu et al., 2009). Consideration

of efficient use of infrastructures for consumptive water uses and environmental water allocation for sustainable ecosystem function of large river basins is crucial for wetland restoration measures and sustainable maintenance of ecosystem services (e.g. Grafton et al., 2013). Finally, the need for strong linkages between scientific community and management stakeholders is essential in order to achieve the goal of wetland ecosystem management and restoration (e.g. Pittock and Finlayson, 2011, Liu et al., 2014). The decision making should be based on the need of the local community and mutual understanding among scientists, resource managers and the community leaders (Poff et al., 2003). The successful outcomes of water resource management in river basins would be possible if the community is engaged with all aspects of water resource management programs including both structural (e.g. hydropower dams) and non-structural infrastructure developments (e.g. awareness in adaptation to change), as well as water saving (e.g. Shen, 2010). The proposed adaptive water resource management framework (Fig. 7) is expected to enhance wetland resilience by improving both water quality and quantity, including ecosystem function, consequently assisting the basin-wide management of food and water security issues through extensive community participation. For example, the WWF-supported partnership program, together with government agencies and local communities, was highly successful for improving water resources, both quantitatively and qualitatively, in the Yangtze River Basin. Under this type of management program and in partnership with local people, the three Yangtze lakes (Zhangdu, Hong and Tian-e-zhou), which were disconnected from the main channel during the 1950s-1970s, have now been recharged by opening of sluice gates (Yu et al., 2009). The recharging of Zhangdu Lake has not only enhanced resilience of the lake environment to climate change and but also livelihoods of the local people (Yu et al., 2009). Recently, the role of community participation in water resource management has also been reported significant in an Australian river basin. For example, the coupled socio-hydrologic models have shown strong association between the trajectory of human-water co-evolution and associated goods and services in the Murrumbidgee River basin (Kandasamy et al., 2014). SPECIFIC COMMENTS: 1. As the paper currently stands,..the title overemphasizes the development of an adaptive water management framework as a key contribution and goal of the paper (see my comments above as to why this does not seem appropriate). Perhaps the authors could focus the title more on the hydro-ecological evolution of the basins given the strengths of the paper? Answer: The title has been modified as per the suggestion from the reviewer. “A century scale human-induced hydro-ecological evolution of wetlands of two large river basins in Australia (Murray) and China (Yangtze): Development of an adaptive water resource management framework”

2. p.8252 L4-5: compared with what previously? A before and after comparison of sediment load would strengthen this point. Answer: This section has been described for the role of flow regime, the comparison of sediment load prior and after has been given. 3. p.8253 second paragraph: it may be worth reaffirming the socio-economic importance of this to highlight the message of why the authors are working up to an adaptive water resource management framework. Answer: This issue has been addressed in the revised version. In Section 1.0 following statements have been added to address the broader issue of eco-hydrology and water resource management. Section 1.0 “. . .The important socio-economic benefits, such as water quality improvement, flood abatement, and carbon sequestration, that are maintained by wetland biodiversity and ecosystem functioning will not be impaired if the wetlands of large river basins are not lost or degraded (Zedler and Kercher, 2005). . .” “. . .Recently, Pawlowski et al. (2015) have documented the cladoceran-inferred palaeo-hydrology, including the formation of meandering channels, hydraulic characteristics and water level change, in the oxbow lake of the Grabia River (central Poland) during the late Glacial and Holocene periods. Whereas the role of fossil cladocerans is becoming increasingly significant for understanding the past hydrology of large river basins elsewhere, understanding cladoceran response to long term hydrology and water level change of wetlands (eco-hydrology) in the Murray and Yangtze rivers is more limited. . .” “. . ..Understanding the linkage between eco-hydrology and adaptive water resource management or ‘socio-hydrology’ is increasingly important in large river

basins, since interaction between people and water is fundamental (Nilsson and Berggrern, 2000). However, the use of palaeoecology (subfossil cladocerans) is rarely examined in rapidly changing environments nor is its role in socio-hydrology. A participatory approach of water resource management has been found to be successful in many regulated environments (Falkenmark, 2004). Such an approach is sustainable in nature and has increased levels of integration between natural and social scientists, land and water users, land and water managers, planners and policy makers across spatial scales (Macleod et al., 2007). This type of integrated platform is crucial for learning and exchange of knowledge among stakeholders for successful management outcomes (Pahl-Wostl, 2009). Based on evidence from subfossil cladocerans, we have proposed an adaptive water resource management framework for the Murray and Yangtze River wetlands.” 4. Section 2.2: this is an excellent description of the site. By comparison, the description of KB (section 2.1) comes across as a little superficial and would benefit from greater context (e.g. climate) and statistics in terms of impacts. Answer: The description of Kings Billabong (Section 2.1) has been rewritten and made comparable to Zhangdu Lake. Section 2.1 “Kings Billabong (34° 14’ S & 142° 13’ E) is a shallow (∼1.8 m deep) wetland (210 ha), located along the River Murray near Mildura (northwest Victoria), Australia (Fig. 1). Kings Billabong was once an important source of food and water for the Nyeri Nyeri Aboriginal Community. The intensification for agriculture around Kings Billabong by early European settlers began in 1891 until 1923. Initially in 1896, the Kings Billabong was used as a pumping station and converted to water storage basin (Lloyd, 2012). Modification of the landscapes around the billabong and construction of dams, including the series of locks and weirs for upstream water storages, have significantly altered the natural flow regime of the River Murray feeding Kings Billabong (Gippel and Blackham, 2002). The hydrology and, in particular, variability of flows including duration and water retention time in the river, have substantially influenced the volume of water in Kings Billabong (Lloyd, 2012). Since formal regulation of the River Murray began in 1927, with construction of Lock 11 at Mildura and Lock 15 at Euston in 1937, downstream river flows and naturally occurring flood pulses have altered in many wetlands, including Kings Billabong (Gippel and Blackham, 2002). The artificial flooding linking Kings Billabong to the weir pool of Lock 11 has led this wetland becoming permanently inundated. The first sign of impact due to river regulation on Kings Billabong was observed as widespread dieback of River Red Gum (RRG) forests and establishment of fringing Cumbungi (Typha sp.) vegetation (Parks Victoria, 2008). Logging of RRG forests was intensified in the region until the 1950s, with the timber used to fuel steam-operated pumps and paddleboats along the River (Parks Victoria, 2008). The life cycle of native aquatic biota in the wetlands around the lower Murray has become disrupted due to the variation in natural wet-dry events caused by river regulation (Ellis and Meredith, 2005). Increased distribution range of exotic fish and weeds were also observed following regulation. For example, in a survey of native and exotic fish in Kings Billabong Gambusia (an exotic species) comprised 35% of the total species collected (Ellis and Meredith, 2005). Apart from human activity, climate change has also impacted the condition of Kings Billabong. Average water temperatures in the Southeast Australia have risen over the past 60 years and there has been a decrease in 40% of the total rainfall in the region (Cai and Cowan, 2008). This regional variability in climate change has led to significant changes in river flow, wetland volume, thermal structure and alteration of catchment inputs, all of which are influenced by a marked increase in frequency and intensity of extreme events such as droughts and floods (e.g. Lake et al., 2000). 5. Section 2.3: is there an inconsistency here? The lake area is listed as 304.3km2 and 22067ha. Answer: Thank you. The inconsistency in unit and the repetition of areas have been clarified. 6. Section 3: I am not convinced that this section adds too much relative to what has already been discussed in sections 1 and 2. As a result it becomes somewhat repetitive. Perhaps sections 2 and 3 could be merged and repetition kept to a minimum, as much of the information in section 2 is repeated without a great deal of additional context or takeaway messages. Answer: This section is important to describe the hydrology of the study sites, thus this has been kept. In the revised manuscript, the entire section is rewritten (Section 3.0). The section now

is, concise and convincing (please see the general comments). Section 3.0 "Figure 3 presents hydrological frameworks for both Murray and Yangtze River systems. This diagram shows the deviation of baseline flows of two rivers and associated wetlands before and after regulation. Construction of weirs in the lower Murray River during the 1920s-1930s, and construction of dams in the Yangtze River during the 1950s – 1970s significantly altered peak flows and downstream wetland hydrology (Lloyd, 2012; Yang et al., 2011a, b). Naturally occurring spring flood patterns in the River Murray prior to the construction of Lock 11 in 1927 have been altered by regulation. As a result, the amount of water released to meet peak irrigation demands has changed (Lloyd, 2012). Increased demand for water has resulted in the flow of the Lower Murray River falling below the historical baseline (Fig. 3 A-i). Regulation for wetland permanency has led to the depth of Kings Billabong being above the historical baseline level (Fig. 3 A-ii). In Zhangdu Lake, water levels were maintained through inflows from two rivers, the Daoshui River from the west and the Jushui River from the east, and outflow to the Yangtze River via by an artificial channel from the southeast corner of the lake. The water level was maintained by permanent connectivity between the Zhangdu Lake and the Yangtze River channels prior to the 1950s, but became disrupted by regulation (Fig. 3 B-i). The decline in annual discharge of the Yangtze River (−11%) after the 1950s (Yang et al., 2011a,b) led to a reduction of the historical baseline flow of the river, subsequently reducing the baseline water level in Zhangdu Lake (Fig. 3 B-ii). The South-to-North Water Diversion Projects as well as wetland reclamation and construction of new dams, particularly after the 1970s-80s, has further altered the hydrology of Zhangdu Lake (e.g. Qin et al, 2009; Yang et al., 2010). However, the project initiated in 2005 by the World Wildlife Fund for Nature has recharged the channel hydrology and increased water level of Zhangdu Lake (Fig. 3 B ii)." 7. p.8258 L13-15: is reservoir construction the sole reason for the two preceding trends? It is not immediately apparent why increased water consumption would result in increased dry season discharge of the Yangtze river. Could you please clarify this point? Answer: This section has been rewritten and the issue has been clarified (please see above Section 3). 8. Section 4.1 L18-19: is this sentence complete? Answer: Completed 9. Section 5.1: a finding of greater diversity post interference seems counterintuitive. p.8265 L8-11 cites evidence contrary to this finding. I would suggest the authors attempt to place the present findings into context at this juncture, given their contradictory nature. Answer: This is an important question. The issue has been addressed in revised manuscript by adding the following statements in Section 5.1. Section 5.1 "……The N2 diversity index of cladocerans reflected a small change in both river systems. The Hill's N2 diversity index assumes that the number of species in an ecosystem is uniformly distributed (Hill, 1973) therefore the distribution of cladoceran species along the temporal scale should be uniform. In Kings Billabong the N2 diversity was low during the 1900s. However, prior to human disturbance of the river (c. 1870s), as well as in c. 1960s, N2 Index was relatively high (Figure 5). In Zhangdu Lake, the N2 diversity index prior to the construction of the dam (c. 1881-1954) was low compared to the post-dam construction period, during which time the taxa preferring disturbed environment increased (Fig. 5). Similarly, the N2 diversity index of Liangzi Lake during the earlier period (c. 1900-1930) was lower than post dam construction period in the Yangtze River (Fig. 6). The intermediate disturbance hypothesis (IDH) suggests that the species diversity would increase at a moderate intensity of disturbance (Townsend and Scarsbrook, 1997). The increased N2 diversity index in Yangtze River wetlands following the construction of dams suggests the likely existence of IDH. However, unlike the Yangtze River wetlands, human disturbance in Kings Billabong would have been sudden and severe, due to the arrival in the late 1800s of Europeans, who rapidly transformed the landscape." 10. Section 6.2: I found much of this section to be quite repetitive. The detailed discussion of population levels and species, although well supported by literature, comes across as overly detailed. This is especially since, by this point, given the expectation created by the title of the manuscript, I was expecting the discussion to take a more high level focus (i.e. what do these changing population levels mean to higher level ecosystem services and to the socio-economic context). Although this is touched upon briefly in parts, the

larger scale message is lost in the detail. This would provide a more intuitive link to then build an adaptive water resources management framework. As it stands, this section has a purely eco-hydrological focus, which is still compelling if a little repetitive. As I said in my earlier comments, de-emphasizing the AWRM focus upfront would most likely alleviate most of these issues. Answer: In the revised manuscript, both issues: repetition and linkage between eco-hydrology and adaptive water resource management have been resolved. The changing water quality and population levels of biota following regulation have now been linked to changing biodiversity, ecosystem services as well as other socio-economic contexts such as conflicting demands of natural resources (Please answers under general comments Section 6.2). 11. Section 6.3 p.8271 L4-6: This is a sweeping opening statement that seems disconnected from the rest of the paper. I do not believe the case for this has been convincingly made to this point (i.e. no discussion of higher level impact or literature citations in this regard). The focus of the paper to this point has consistently been on the detail (i.e. shifts in population composition and diversity at the subfossil cladocedan level) rather than on a connection with socio-economic impacts and river basin management. If the authors choose to retain this section, I believe this link needs to be made much more clearly and convincingly throughout. Answer: This entire section has been rewritten. Relevant high level literatures have now been cited. The focus of the paper is on the shift in population composition and diversity at the subfossil cladoceran levels. The reviewer is correct, the aim for this section is to connect this with socio-economic impacts and river basin management, thus chosen to retain this section, and in the revised version all issues have been convincingly addressed (Please see Section 6.3). 12. Section 6.3 p.8271 L14-19: the authors may wish to look at recent literature outlining the evolution of management focus in sub-basins of the Murray river which actually show a shift in focus from socio-economic to environmental water allocation (e.g. Kandasamy et al. (2014)). Answer: Thank you. This reference has now been added. 13. Section 6.3 p.8271 L20-23: This is a very ambitious claim (i.e. "taking into account the historical environmental, technological, economic, institutional, cultural, and social values") which I do not believe the model achieves in its current simplistic state. This statement is unsubstantiated within the context of the presented framework. Answer: This statement has now been modified based on our study (please see Section 6.3). 14. Section 6.3 p.8271 L23-26: As with my comment above, I do not believe the authors show sufficient regard for what "integrated" means in the context of a management framework. There is significant debate in the literature discussing the pros and cons of integrated water resource management, with one of the primary issues being the challenges associated with defining an "integrated" system (e.g. Biswas (2004)). Answer: Thank you. The debate on ‘integrated’ concept has now been extended in the revised version including the incorporation of Biswas (2004). Please see answers above under general comments Section 6.3. 15. Section 6.3 p.8272 L22-24: The three restoration pillars proposed are very vague, e.g. what does "efficient water allocation" mean? How is this measured? Similarly, L25 refers to improving "livelihoods", "institutional capacities" and "the value of efficient infrastructure" - how would each of these be defined/ measured? I do not believe the authors have convincingly presented a case for this framework. A number of concepts are introduced, none of which are easily measured or translatable to reality, and thus the paper does not provide any useful guidance for practical application. If the authors choose to retain this section, I would suggest building a much stronger foundation from the literature to demonstrate a greater depth of understanding, as well as including practical/ real case examples to illustrate their propositions. Overall, I feel that 6.3 lets the paper down as it is not well supported. Answer: This is an important advice. In the revised manuscript, the three restoration pillars: science, engineering and community participation are described in details with stronger foundation of literature (please see answers above in General comments Section 6.3). 16. Fig. 3: Why are all graphs identical despite KB being converted to a permanently inundated wetland vs other lakes which are dehydrated? Answer: The Fig. 3 is a conceptual framework for hydrology of the large river floodplain wetlands. All graphs look identical as these conceptual graphs represent how wet and dry cycle (flood pulse and pause) occur in floodplain wetlands.

TECHNICAL CORRECTIONS: As a quick note, there are a great deal of minor typos and written/ grammatical mistakes so I would urge the authors to review the paper in detail. Answer: These issues have been carefully looked at and corrected. 1. p.8251 L10: delete "the" before "two of" Done 2. p.8251 L22-26: the addition of a reference that reinforces the broad evolution of this river basin would be useful here. Ref added 3. p.8251 L27: insert "the" before "majority" Done 4. p.8252 L12: insert "the" before "Yangtze River" Done 5. p.8252 L25: insert "a" before "characteristic state" Done 6. p.8253 L12: assess should be "assessing" Done 7. p.8253 L26: delete "a" before "large scale" Done 8. p.8254 L1: insert "an" before "adaptive" Done 9. p.8254 L9: delete either "to" or "until" before "1923" Done 10. p. 8254 L12: insert "the" prior to "natural flow" Sentence rephrased 11. p.8254 L18: delete "in 1927" (twice in same sentence) This should have been 1937 12. p.8255 L11: insert "the" prior to "Yangtze" Sentence rephrased 20. p.8255 L12: insert "the" before "Yangtze" Sentence rephrased 21. p.8256 L23: delete "projects" (repeated twice) Fixed 22. p.8257 L2: do you mean "changes in ecosystem structure"? All section rewritten 23. p.8258 L9: insert "the" prior to "wetland" All section rewritten 24. s5.1: check figure numbering - I think you mean to refer to Figs 4 and 5 Resolved 25. p.8262 L1: delete "until the 1980s..." Done 26. p.8262 L23: insert "to" before "this change" Done 27. p.8263 L21: insert "a" before "decrease" Done 28. p.8264 L13: "2000s" Done 29. p.8264 L18: "within" the Murray and Yangtze? Done as suggested 30. p.8265 L13: delete "that" before "of natural" Done 31. p.8267 L4: check spelling of Liangzi Corrected 32. p.8267 L10: do you mean "decrease in water quality"? Corrected 33. p.8267 L13: "little or no impact" Done 34. p.8267 L17: should be "prefer" Done 35. p.8271 L3: I think you mean "these three wetlands suggest that water resource...." ok 36. p.8272 L20: should this be "changes to ecosystem functioning"? Comprehensively written 37. Fig. 1 caption: insert "the" before "wetland" Done 38. Fig. 3 caption: I think you mean "Kings Billabong’s conversion to..." Done 39. Fig. 7 caption: L4 & L5 insert "the" before "ecosystem"; L8 delete "expected" Done 40. Check date inconsistencies of references: Gell (2014 vs 2015 should be 2014 Done); Kattel et al. (2014 vs 2015 should be 2015 Done); Van den Brink (1993 vs 1994 should be 1994 Done); Yang et al. (2011a vs b, corrected) REFERENCES Biswas, A. K.: Integrated water resources management: a reassessment, Water International, 29, 248-256, 2004 (added) Kandasamy, J., Sounthararajah, D., Sivabalan, P., Chanan, A., Vigneswaran, S., and Sivapalan, M.: Socio-hydrologic drivers of the pendulum swing between agricultural development and environmental health: a case study from Murrumbidgee River basin, Australia, Hydrol. Earth Syst. Sci., 18, 1027–1041, doi:10.5194/hess-18-1027-2014, 2014 (added) NEW REFERENCES ADDED IN THE REVISED MANUSCRIPT Biswas, A.K.: Integrated water resources management: a reassessment, Water International, 29, 248-256, 2004. 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