Nat. Hazards Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/nhess-2020-72-RC1, 2020

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "What controls the coarse sediment yield to a Mediterranean delta The case of the Llobregat river (NE Iberian Peninsula)" *by* Juan P. Martín-Vide et al.

Carles Ibáñez (Referee)

carles.ibanez@irta.cat

Received and published: 3 April 2020

Very interesting paper that, however, shows some important caveats that need to be solved before a decision of publication can be made. The paper needs a major change in the focus and the specific goals to sort out the weak points that contains right now. The starting point is the observed secular coastal retreat of the Llobregat Delta. This is an interesting new piece of information that gives value to the manuscript but at the same time shows the limitation of the approach taken. For me it was a surprise to see that the Delta was already retreating quickly by the end of the XIX century and that the retreat kept going all over the time till nowadays. This is very interesting, but in my opin-

ion the possible causes argued in the manuscript to explain it are not convincing. In terms of damming the authors mention two dams built in the last decades in the upper basin, while river channelization is also relatively recent and cannot be the main cause of such a dramatic coastal erosion. The main argued possible cause is reforestation, but again the process is not so widespread from the beginning of the observed retreat and the increase in forest cover along the study period is not so large to explain the most of the deficit in sand delivery to the delta. According to Table 2 forest shifted from a cover of 63% in 1956 to a cover of 70% in 2009 for the whole river basin, and this is the main period of afforestation, mostly driven by the abandonment of traditional farming and public policies during the last decades of the dictatorship regime. At the same time, data also shows that large floods (a major source of sand delivery to the coast) have apparently been occurring all along the study period (a more detailed analysis of the changes in river floods along time could help to understand what's going on). There must be other causes to explain the sediment deficit in the delta, and the main one that comes to me is the widespread construction of weirs in the Llobregat River and its main tributaries (such as the Cardener) for industrial production (mostly textile) and for hydropower, that was already important in the XIX century. This chain of small reservoirs certainly modified in a dramatic way the hydro-sedimentary dynamics of the Llobregat River and tributaries, and could mostly explain what happened in the Llobregat Delta in terms of erosion. Thus, the paper needs to investigate this point as much as possible, both in terms of data (on the evolution of damming in the basin), mechanisms (how this damming modifies the sedimentary dynamics) and potential effects on sand delivery to the coast. In relation to the other analysed mechanisms that could explain in part the changes in river sediment dynamics and delivery to the coast (section 4), I have some other relevant comments: Land uses and urbanization: as mentioned in the text the change in forest cover is modest, I do not think it can be claimed as the main reason for the sediment deficit in the delta, though it may have some effect (see Ibáñez et al. 2019 and Nienhuis et al. 2020). Besides analysing the changes in land use, is there any possibility to estimate the relative contribution of this phenomenon to the sediment

deficit? (the same question applies to the other drivers of change in sediment dynamics in the river). Dams (sediment trapping): the authors mention that the percent of sediment retention in the two reservoirs of the upper basin may be proportional to the percent surface area that they close. However, it is well known that most of the erosion worldwide comes from the upper parts of the river basins. See for instance Wilkinson & McElroy (2007): Consideration of the variation in large river sediment loads and the geomorphology of respective river basin catchments suggests that natural erosion is primarily confined to drainage headwaters; âĹij83% of the global river sediment flux is derived from the highest 10% of Earth's surface. Then one should expect a higher proportion of sediment retention due to the two dams, which would be concentrated in the last decades, after dam construction. Dams (hydrological changes): I am not sure it's a good idea to combine the effect of dam regulation with river engineering to estimate changes in sediment delivery to the coast. In any case, it would be important to have at least an estimate of the change in carrying capacity for the whole river, not only the lower basin. Climate change (rainfall and runoff): this possible driver of change in sediment delivery to the coast has been neglected and could be significant. Sand transport capacity is mostly driven by river flow, so changes in river flow due to changes in rainfall and runoff could play a significant role. This possibility should be analysed (see Xing et al., 2014). Channelization and flood plain alteration (river engineering): again the analysis of the alteration of the river bed and the alluvial valley focuses only in the lower river basin, but is quite clear that most of the river basin is engineered (including small dams and other works). So, what is the global contribution of river engineering to the reduction of sediment delivery to the delta? Please try to make a global estimate if possible. Sand mining: it is mentioned but it would be interesting to have more quantitative information to know the relevance of this activity on the sand deficit to the delta. Other relevant comments regarding beach retreat (section 3): It would be interesting to add an extra graph or table to assess the evolution of the coastal erosion in the delta all over the study period, for instance in the river mouth, in order to see if there is any trend along time and also try to see if this trends match

with the assessed trends in sediment delivery to the coast. Sediment dynamics in the delta: "The reach is a sedimentary unit throughout the whole period 1891-1981" (lines 60-61). This is not strictly correct, depends on the interpretation of the sentence. Figure 3 shows two different sedimentary units "erosion-accretion" (quite typical in many deltas). This is likely explained by the existence of an old river mouth around Km 10. So it is a sedimentary unit composed by two sub-units. Limits of the Llobregat Delta and sand losses Southwards: "An oval contour slightly protruding into the sea, geographically speaking the delta, can be assigned to the length between x=15 and x=24 km, being the river mouth at x= 21 km" (lines 73-74). "The calculation yields a deficit of 57.000 m3/yr in the delta (x= 15-24 km) and a surplus of 29.000 m3/yr in the beaches west of it (X= 0-15 km)" (lines 93-94). The two sentences should be modified, since the delta is the whole stretch from km 0 to km 24. All deltas have sections with erosion and the corresponding sections with accretion due to the eroding stretch located "upstream" (in relation to the long-shore transport). "The negative balance (loss of sand) can be explained by the partially open western boundary (at x=0)" (lines 101-102). I am no sure that this is the correct explanation. Is there information showing that this volume of sand leaving the delta (quite a lot) is accumulating nearby? Could be the case that there are errors in the calculation of the sediment budget?

Last but not least I recommend to change the structure and title of the manuscript. I suggest something like: "Changes in coarse sediment delivery to the coast during the last century in the Llobregat River: causes and consequences". In terms of structure I would simplify it and present data in a more integrated way, including a table summarizing the estimated contribution of each component to the changes in sediment delivery and what are the data gaps necessary to get a better estimate.

References Ibáñez, C., Alcaraz, C., Caiola, N., Prado, P., Trobajo, R., Benito, X., ... & Syvitski, J. P. M. (2019). Basin-scale land use impacts on world deltas: Human vs natural forcings. Global and planetary change, 173, 24-32. Nienhuis, J. H., Ashton, A. D., Edmonds, D. A., Hoitink, A. J. F., Kettner, A. J., Rowland, J. C., & Törnqvist, T. E.

(2020). Global-scale human impact on delta morphology has led to net land area gain. Nature, 577(7791), 514-518. Wilkinson, B. H., & McElroy, B. J. (2007). The impact of humans on continental erosion and sedimentation. Geological Society of America Bulletin, 119(1-2), 140-156. Xing, F., Kettner, A. J., Ashton, A., Giosan, L., Ibáñez, C., & Kaplan, J. O. (2014). Fluvial response to climate variations and anthropogenic perturbations for the Ebro River, Spain in the last 4000 years. Science of the total environment, 473, 20-31.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., https://doi.org/10.5194/nhess-2020-72, 2020.