Understanding the Cambodian Upper Mekong Delta:

Towards New Approaches for Floodplain Governance

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All remote sensing maps presented in this report have been prepared by Christina Orieschnig unless otherwise stated. Agriculture and fishery analysis are based on a large number of interviews conducted in Kandal province and in Phnom Penh and heavily draw from the work of Paul Vandome (agricultural systems), Melvin Frick (pesticides), and Raksmey Phoeurk (fisheries). Participatory activities have been designed an implemented collaboratively by IRD, CIRAD, ISC and RUA staff. Hydrological monitoring of the prek area is implemented and analyzed by IRD and ITC staff.

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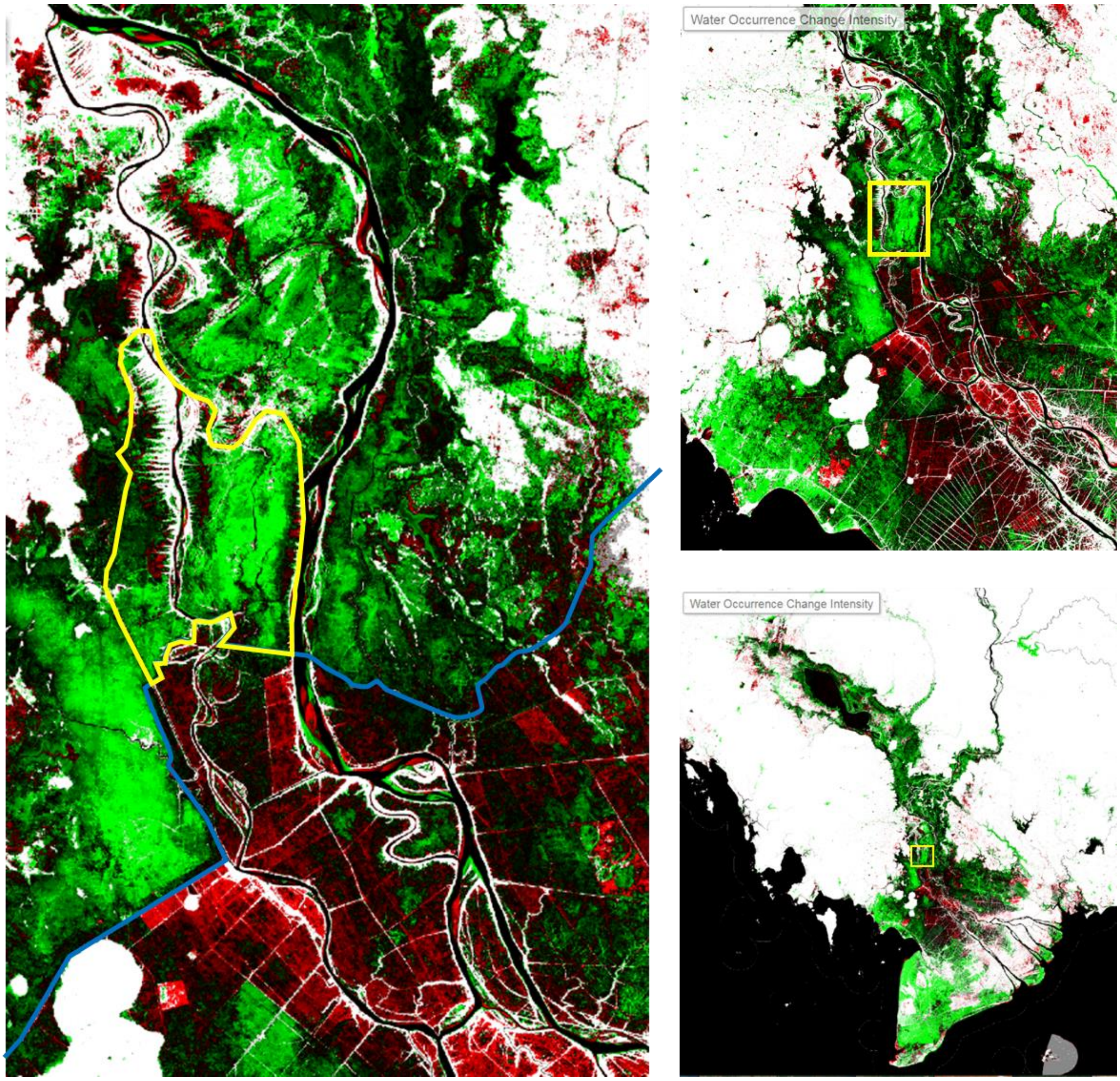
Setting the Scene

- A flood prone area with relatively little water control that offers a stark contract with the water infrastructure development path followed in Vietnam.
- High variability in flood patterns (inception, duration, recession) over recent years.
- Ongoing projects focused on increasing water availability in the dry season for intensive cultivation through the construction of water infrastructure.
- A heterogenity of socio-environmental systems that calls for tailored approaches.

Figure 1. Change in water occurrence in the Upper Mekong delta: Contrasting views from Vietnam and Cambodia (Source: Adapted from Pekel et al., 2016). In red, mostly in the upper part of the Vietnamese Mekong deltas, are areas where flood occurence has decreased over the last 40 years due to the widepsread construction of dikes; in green are areas where flood occurence has increased over the same period.



- Floods long identified as an issue and an obstacle to the productive use of floodplains.
- Since the 1960s (UNESCO, 1966), the construction of hard infrastructure (for flood protection and agricultural intensification) has been the dominant approach in deltaic floodplains. One of the most 'iconic' example of such approach is the Vietnamese Mekong delta (see figure 1; also Biggs, 2008; Molle and Tuân, 2006).
- Such approach is increasingly questioned by scholars (e.g. Wesselink et al., 2015) and international organizations who are now calling to build with, instead of against, nature (WWAP & UN-WATER, 2018). These calls are linked to several observations related to in-situ deltaic dynamics but also to processes that take place "outside" the floodplains but impact them significantly:
    - Intensive agriculture (esp. rice cultivation) has reached a "plateau".
    - Controlling water means changing sediment flows, which leads to (1) lower land fertility and yields in the deltaic floodplain (Dung Duc Tran et al., 2018) and (2) costal erosion + sinking deltas (Syvitski et al., 2009; Renaud et al., 2016).
    - At the same time, there is a trend towards the recognition of the environment not only providing the ground for agricultural intensification but providing other services – in the Mekong, fishery being the most iconic example.
    - Large dam construction has caused significant changes in the hydrology of the Mekong, wih increased flow variability oberved after 2008 when dam construction on the Mekong mainstream and its affluent accelerated (e.g Han et al., 2019; Yun et al., 2020). Climate change is a further stress with increased incidence of extreme events and higher unpredictability in weather patterns.
    - Protective strategies based on controlling water flows can become counterproductive as they 'displace' risks and possibly lead to worse impacts in case of crisis (as shown in Katrina case – Horowitz, 2020- where ever more water control is said to have largely contributed to more detrimental impacts).

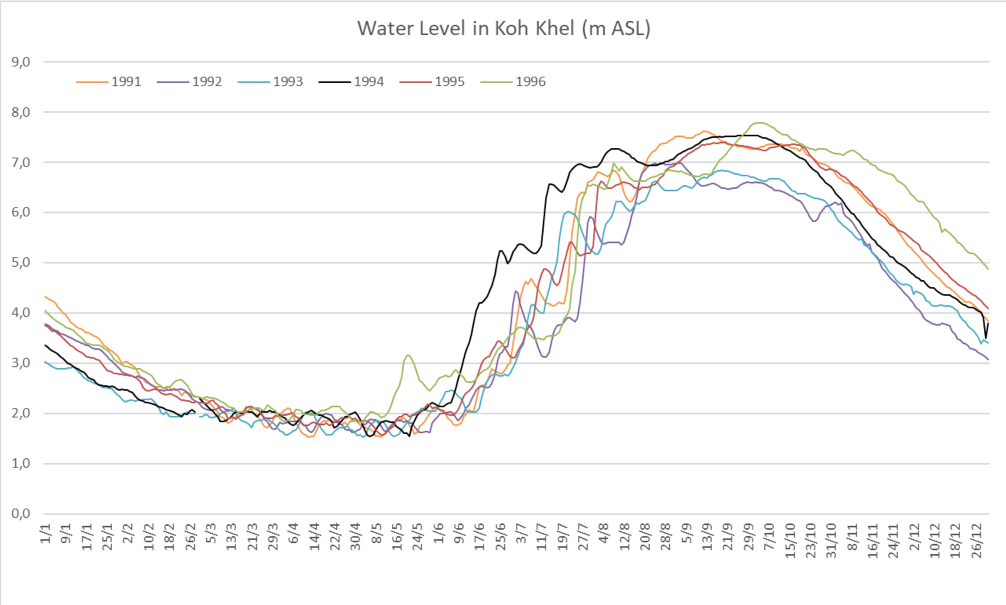
⇨ The deltaic floodplain of the Cambodian Upper Mekong Delta offers a perfect opportunity to engage with these global debates, as there is (still) little water control but a trend towards infrastructure development.

⇨ The central issue is to assess the differential impacts these changes will have on local livelihoods and agricultural/fishery systems AND to imagine new, more adaptable and fluid ways of developing the floodplain so they continue playing their central role in terms of food security while offering a way to deal with this higher uncertainty in flows. A question relates to the form water infrastructure development should take in a context of (1) low profitability of rice cultivation though it is high on the policy agenda; (2) importance and decline of fishery – a major concern at the level of the Mekong River Commission (e.g. MRC, 2017) but with little evidence of policy action in Cambodia (3) development of intensive fruit and vegetable cultivation with increased used of pesticides/fertilizers that remain largely undiscussed.

Illustrating the global narrative: Hydrological Trends in Kandal

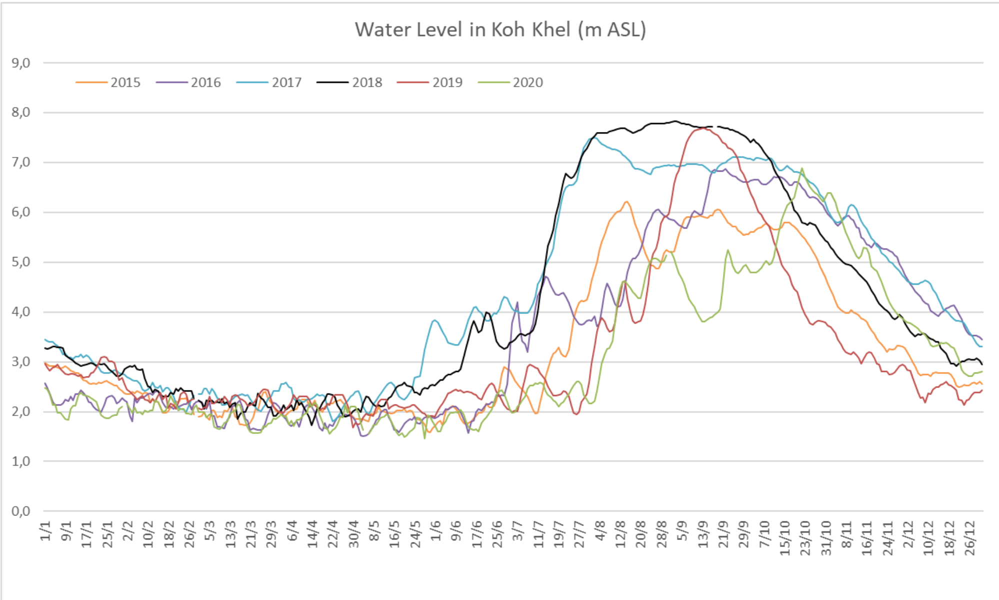
- Over recent years: delay and higher variability in flood inception. Higher variability in flood duration and peak flood level and overall shortening of the flood duration. This impacts the spatial and temporal distribution of floods.

Figure 2. Illustrating high variability in flow patterns in Koh Khel station, Cambodia (Source: based on MRC Data; https://portal.mrcmekong.org/home)



Late 2010s	Flood inception (date)	Flood duration (days)	Flood End (date)	Max water level (mASL)	Date Max
Min	19-juil	22	21-sept	6,21	02-août
Max	15-oct	105	05-nov	7,82	22-oct
Median	31-août	61	13-oct	7,16	07-sept

Flood inception/end considered for water level = 6 m

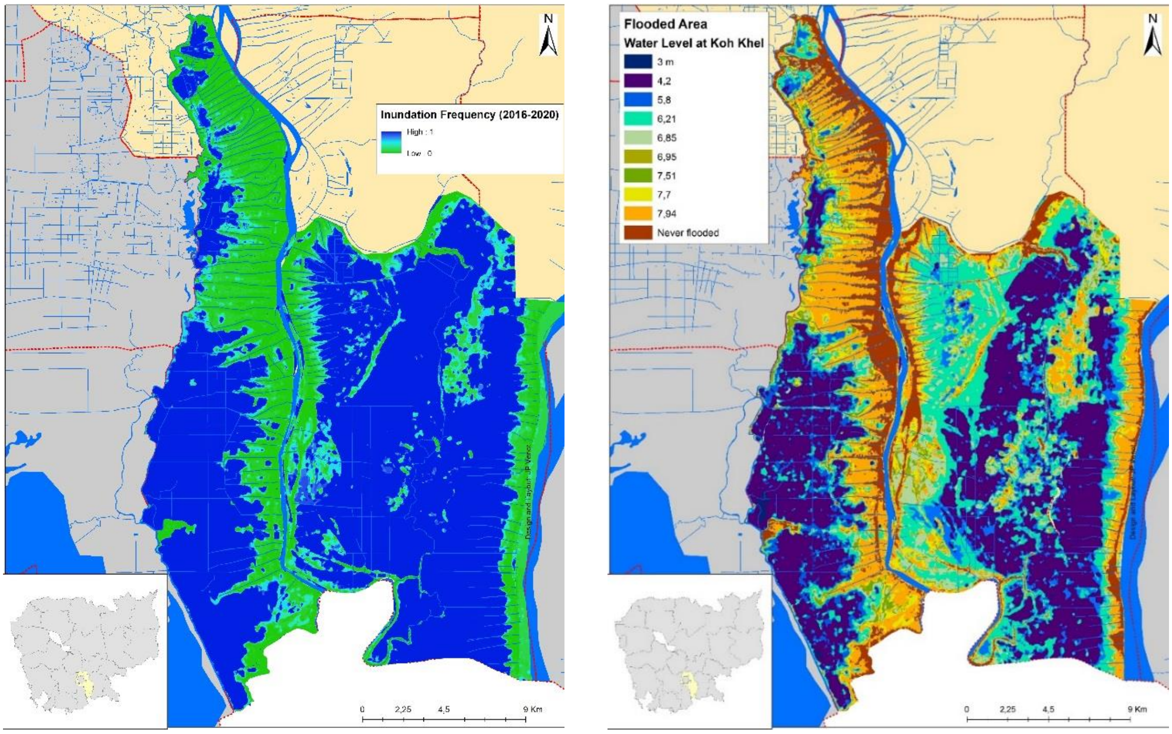


Early 1990s	Flood inception (date)	Flood duration (days)	Flood End (date)	Max water level (mASL)	Date Max
Min	13-juil	68	22-oct	6,85	26-août
Max	16-août	136	08-déc	7,78	02-oct
Median/average	31-juil	106	14-nov	7,36	17-sept

Flood inception/end considered for water level = 6 m

- Uncertainty of flood rise may be problematic for early wet season cultivation, though overall delay in flood may mean this is not much of a problem (apart from 2017 and 2018 when a small early peak has been observed, potentially leading to crop losses)
- Water levels are lower than they used to be in november/december, meaning recession cultivation can take place earlier than it used to. This also mean residual soil moisture may be lower than it used to be later for dry season cultivation.
- Water levels lower in June/July (coupled with rainfall deficit) lead to water stress for dry season cltivation.

Figure 3. Flood frequency and reelation between water level and flood extent



Illustrating the global narrative: Land use and agriculture in Kandal

- Despite low levels of water control infrastructure, Kandal has witnessed large-scale agricultural intensification – mostly through land reclamation for rice cultivation.
- Capture fishery is an overlooked yet extremely important but dwindling resource.

Figure 4. Illustrating land use change between the Bassac and the Mekong

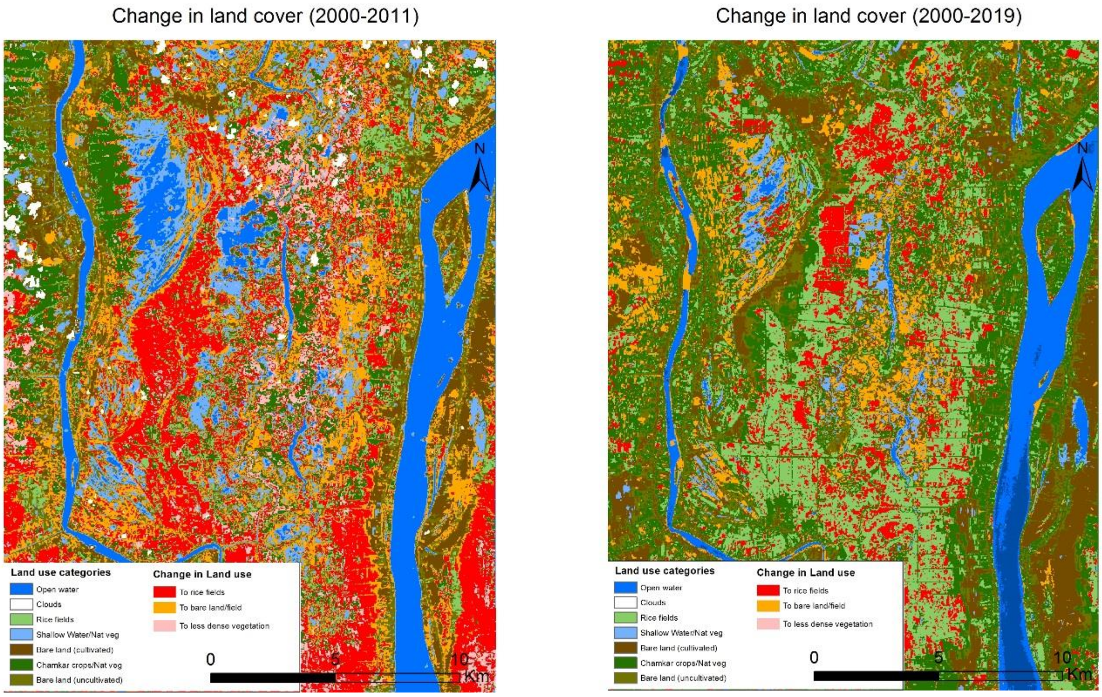
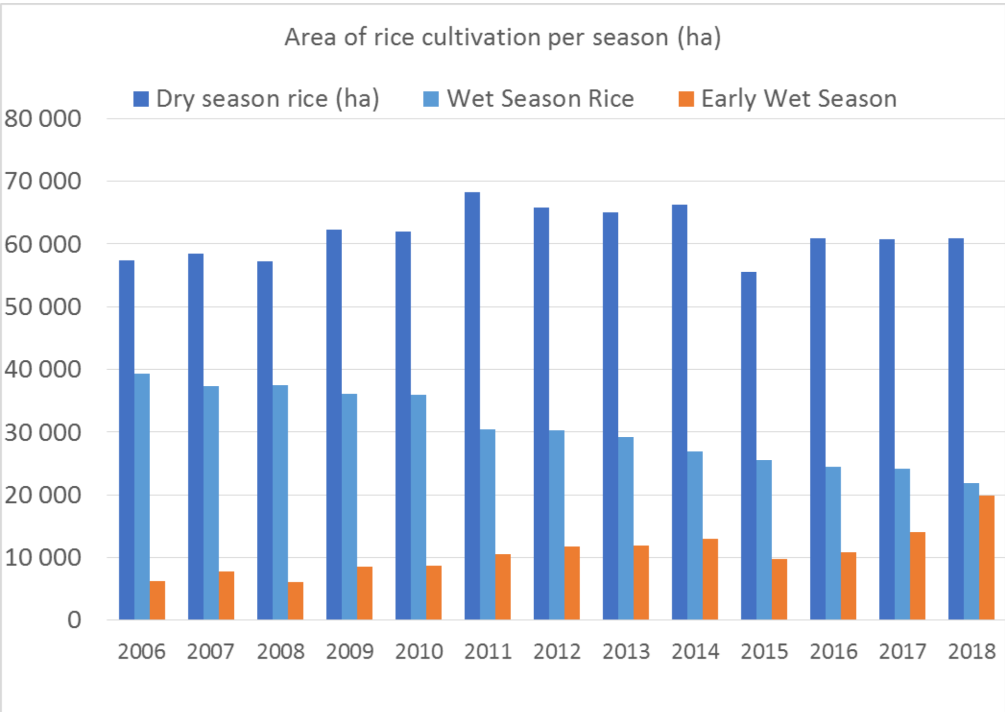
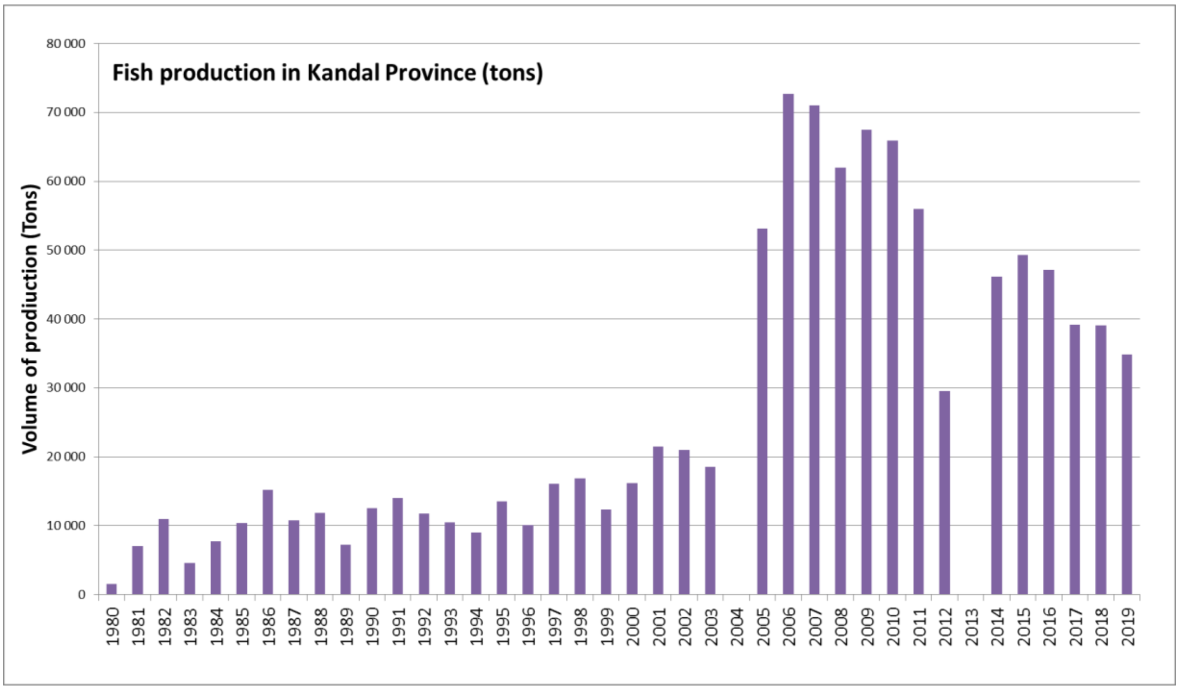


Figure 5. Long-term trends in agriculture and capture fishery catch



- In the south of the province where the COSTEA project is implemented, about 30,000 hectares of land have been reclaimed over the last 20 years (including 10,000 hectares of dense flooded vegetation). Two third of the changes occurred in the 2000s.
- Main trend: increase of early wet season rice multiplied by 3 (+˜15,000 ha; orange on the graph). Likely related in the increased water storage in drainage canals. In the same period,, the number of water pumping devices has also been multiplied by 3 according to MAFF agricultural statistics
- However, interviews point to the fact that water availability remains a key constraint as farmers report a decrease in yield of up to 50% in case of lack of rain during the dry season (Vandome, 2020).
- In 2018, wet season rice cultivated in slightly elevated land was just above half what it was in 2006. Though statistics do not show any increase in annual crops in the wet season (stable at about 16,000 ha) and do not report fruit trees areas, interviews point to a significant extension of fruit trees areas that is likely to have happened at the expense of little profitable wet season rice (gross value of 830 US$/ha/season and added value of 430 US$/ha; Vandome, 2020). This might explain the fact that rice cultivation "goes down" the topography alongside a change in cropping season to the benefit of early wet season rice.
- Dry season cultivation of rice (60,000) and other annual crops (15,000 ha) remain relatively constant (but increase of about 10,000 ha between 2010 and 2015). In the statistics dry season rice cover diverse crop cycles (notably recession rice: Nov/Dec-February also known as recession rice and Feb-May)
- 3rd province in terms of dry season rice cultivation (after Prey Veng and Takeo).

Figure 6. Evolution of fish catch in Kandal province (Fishery administration data)



- Total fish catch in 2019 according to FiA statistics is 35 000 Tons. This is likely to be an underestimate. People living in Kandal are likely to source the fish they eat locally rather than on distant markets. Based on average consumption numbers for Kandal (67,7 kg/person; Hortle, 2007) and provincial population data, total consumption of people above 18 years would amount to more than 57 000 Tons[1].

- Assuming a first-sale price of 1,1 USD/kg (Milne, 2016), Kandal fish production according to FiA statistics amounts to about 38,5 Million USD.
- This is equivalent to the production value of at least 22 000 hectares of rice (considering a yield of 4,8T/ha/season and a price of 750 Riels/kg as in our surveys, and assuming they are cultivated twice ayear). This is likely to be an underestimate given the uncertainty on fish catch volumes in official statistics.
- Population (>12 years) in southern areas between the Bassac and the Mekong is about 45,000 people consuming 2 000 (42,7 kg/ca) to 3 000 Tons of fish (67,7 kg/ca) per year. FAO (2011) reports that fish consumption account for about 45% of all fish catch in Kandal province, pointing out to a potential fish catch of 3500 to 6500 Tons (depending on consumption level) in the floodplain between the Bassac and the Mekong alone.
- This correspond to a first-sale value equivalent of fish catch is between 3.5 and 6.5 Million USD @ 1 USD/kg. This is the equivalent to the value of the production of 4000 to 7500 hectares of rice cultivated once per year. Land use analysis shown in Figure 4 above points to a total area of rice cultivation in the southern area between the Bassac and the Mekong of about 15,000 hectares. **Fish production value would then be equivalent to about half the rice production from this area, assuming all areas are cultivated once a year.**

[1] If population above 12 years old is considered, this increases to 69 000 Tons. If the national average for consumption is considered (42,7 kg/person; according to FAO 2019), numbers are 35 500 Tons (population above 18 years old) and 43,500 Tons (population above 12 years old), respectively.

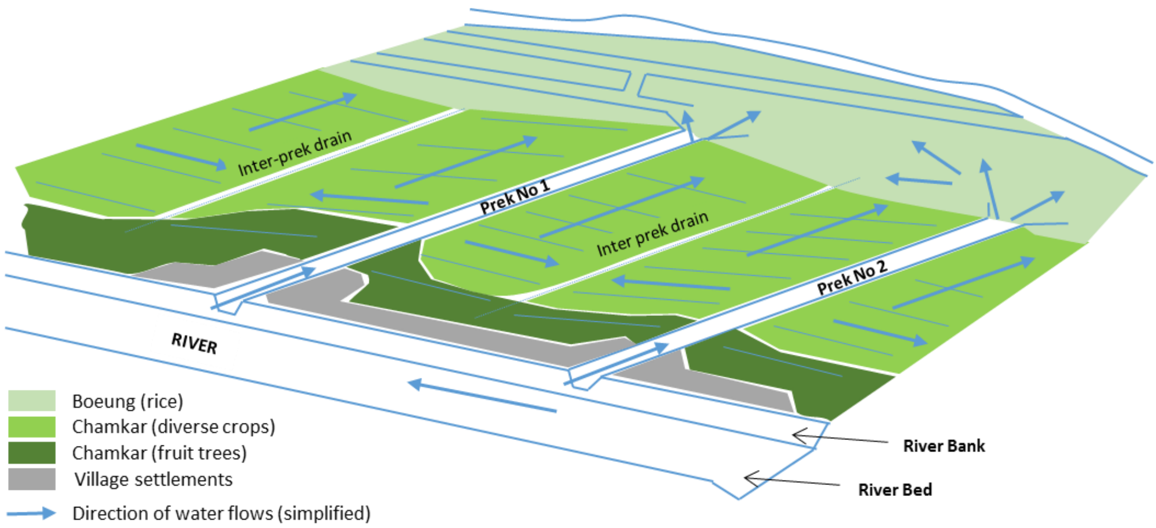
The Prek Mosaic: An Agricultural Tryptic with Gardening, Rice and Fish

- The COSTEA study area constitutes a mosaic landscape.
- This mosaic landscape is crisscrossed by *preks* through which water flows from the main rivers to adjacent low-lying areas called *boeungs* in Khmer.
- The *preks* sustain very diverse agro-environmental systems with significant differences between the right and left bank of the Bassac.

- The first preks were built in the late 1880s for transport purposes. Their importance for sedimentation (siltation) was quickly recognized (leading to the French name still used today: colmatage system) (Venot and Bruun Jensen, 2021)
- They were "re-discovered" in the late 1990s by aid agency (notably JICA, 1998 then AFD in the early 2000). There are more than 250 preks south of Phnom Penh, most of them on the banks of the Bassac and some on the right bank of the Mekong (SOFRECO, 2018).
- They "insert" themselves in a landscape with a three-ways slope (see figure 6) that determines flood pattern and extent
- In the late 1990s, the preks were presented as an example of what would be called today 'a nature based solution' for agricultural development. Two quotes from JICA, 1998 illustrates this:
    - *"the most productive farming system […] in the whole of Cambodia" and stressed "it is also adapted for the natural conditions and utilizes them for agricultural production"* (JICA 1998: 58).
    - "Colmatage farming has many advantages for conducting agriculture harmonized with natural systems".
- Multiple use of preks now recognized but there is still a tendency to see them from an engineering lens, that is as an infrastructure for intensifying chamkar agriculture in the dry season through improved water control (SOFRECO 2018; Venot and Bruun Jensen, 2021). Recent AFD projects are a case in point.
- 25 were preks rehabilitated as part of the WASP project (2015-2019), with debate focusing on the depth of excavation as this determine how long water is available in the canals and can be used for irrigation without pumping from the Bassac River. Another 40 preks are planned to be rehabilitated under the WAT4CAM project. Main difference is looking at adjacent preks (cluster) in what may be an embryo of a network approach (as opposed to the earlier approach of ranking preks according to their characteristics). Yet discussions mostly center on 'preks' (a typology has been elaborated and opens the way to a differential approach to engineering for each type of preks) rather than the land/waterscape in which they are insereted.
- On the right bank of the Bassac, land had been allocated in the mid 1980s during the Krom Samaki period. Lottery system and land holding dispersed in the boeung ➔ Laid the ground for land concentration (see categories below).
- Land in left bank of the Bassac has been first reclaimed in the late 1990s when people moved back to the area after the Khmer rouge period (the geometrical network of drainage canal that can be seen in the area is characteristic of forced labour durint the KR period). People did not stay there and mostly vietnamese people fish in the area. Situation changed progressively changed and this constituted a micro land

frontier. Most reclamation post 2000. Public State land (+ fishery area) so land is claimed but not "owned". Land security is a primary concern

Figure 6. Schematic representation (top) and sattelite images of the prek mosaic landscape (Venot and Bruun Jensen, 2021; adapted from SOFRECO, 2018)



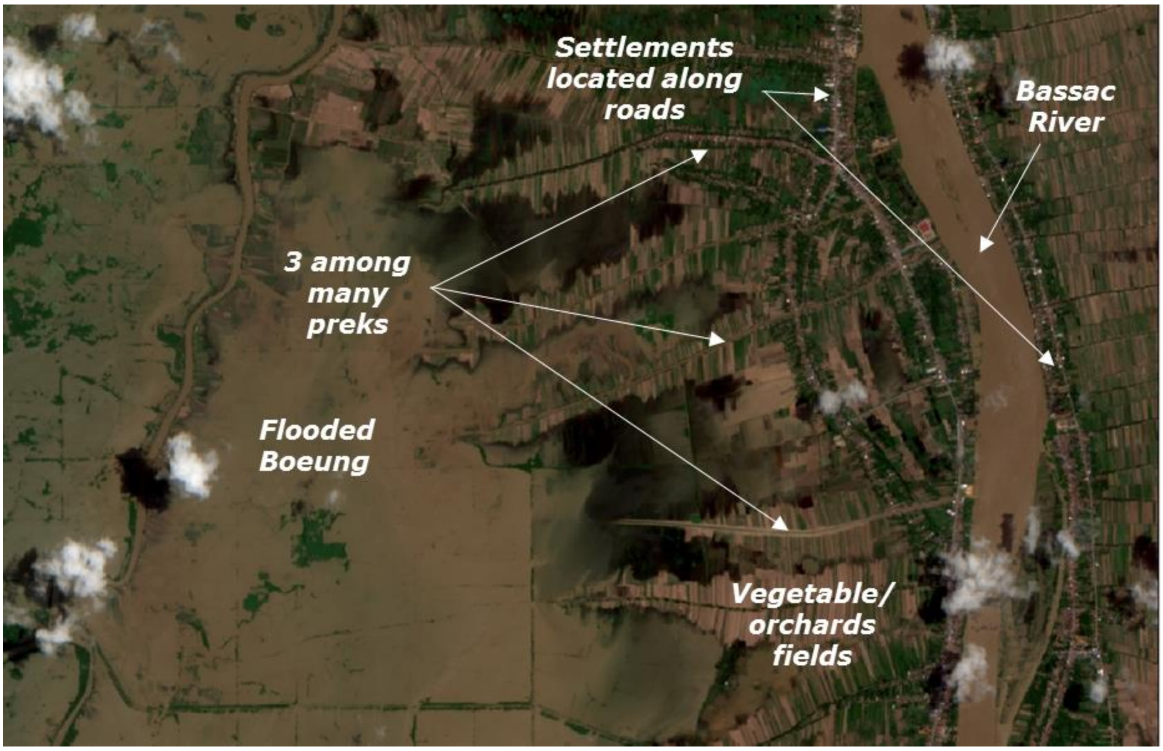


Table 1. Key characteristics of the COSTEA case study area

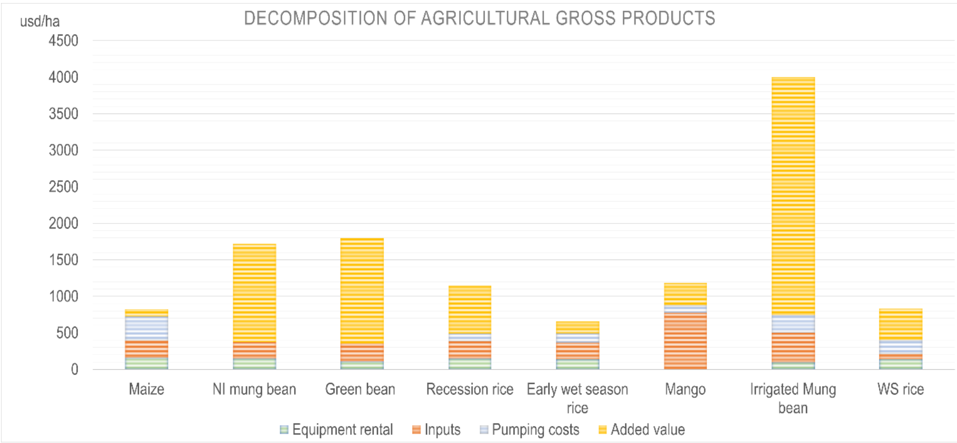
	Total Population	Farmers primary activity	Fishermen Primary activity	Other agricultural work, primary	All agriculture, secondary activity	Agricultural population (% of active pop), including secondary activity	No. of landless people	No. Of people with less than 1 ha	% of landless or < 1 ha
Left/East bank of the Bassac	56707	15588	540	462	8948	68	2074	4019	25
Right/west bank of the Bassac	75057	19953	1222	660	15840	80	3441	6143	29
Total	**131764**	**35541**	**1762**	**1122**	**24788**	**75**	**5515**	**10162**	**27**

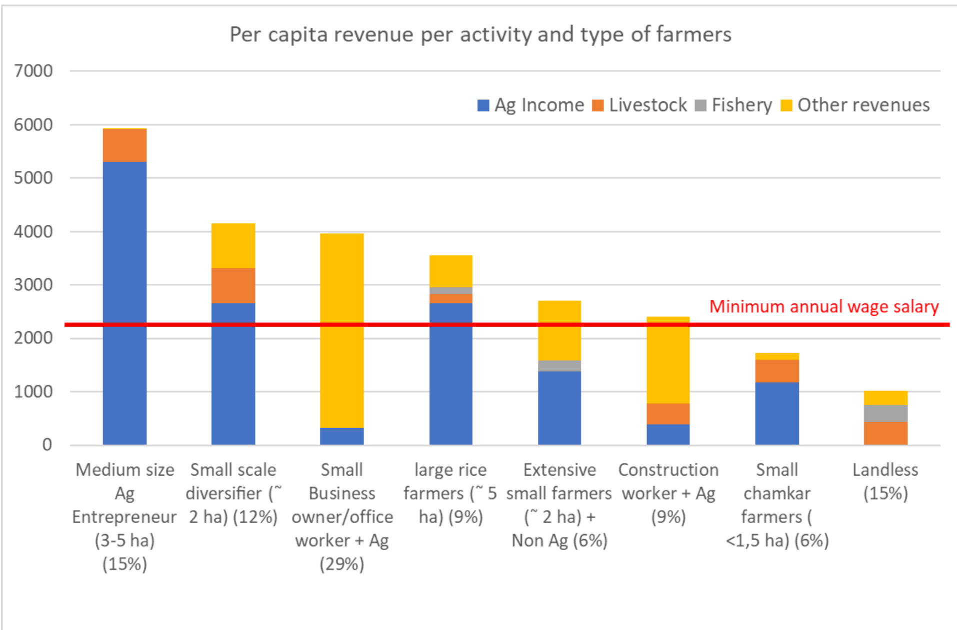
Figure 7: Example of sluice gates build under the AFD funded WASP project (Left: June 2017; right: September 2017)

Agricultural Systems: Diversity and Vulnerability

- There are two main agricultural systems.
- The first one is found close to the levees on areas that are slighly elevated and seldom flooded (yellow to brown areas in the right panel o Figure 3) and known under the term *Chamkar*
- In the Chamkar, diversity of vegetables and fruit trees crops, mostly market oriented. Profitability is high but still constrained by water availability. Farmers use little effective diesel pumps, leading to high pumping cost for irrigation purpose. In this area, securing water availbility could lead to increase in agricultural production.
- There is a large diversity of farming systems with about a third of the households earning less than the per capita minimum wage salary and another third engaged in profitable agriculture either because they cutlivate relatively large areas of land (~ 5 ha) or diversify their practces (see 8).

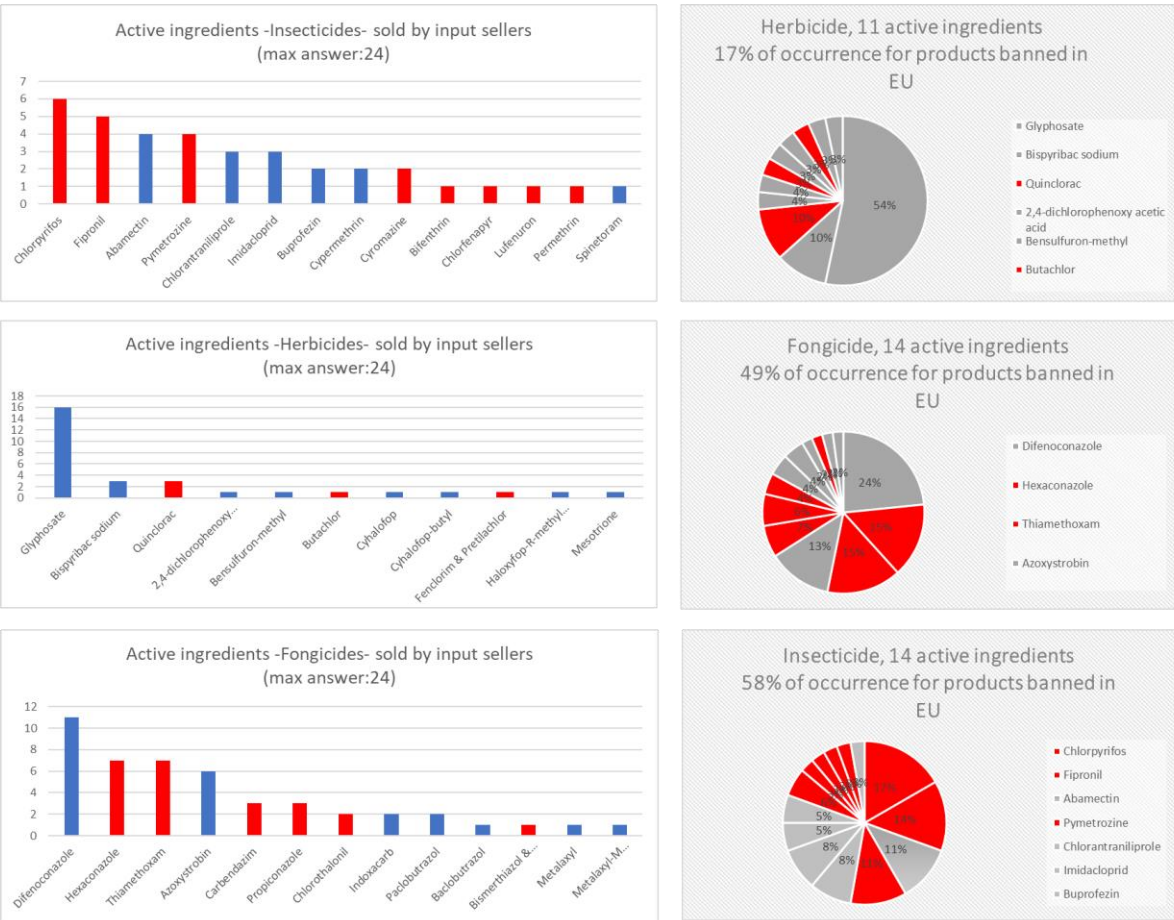
Figure 8. Characterizing farming systems along and around the preks (Source: adapted from Vandome, 2020)





- An emerging issue in the Chamkar relates to increasing use of chemical fertilizers and pesticides. This is recent trend (since the early 2000s) and input are mostly imported. Average use is still about 3 kg/ha; (Schreinemachers et al., 2015).
- Challenge of monitoring pesticides : large diversity of pesticides mentionned by input sellers (77)[2] but an even larger number detected in water (167, only 21 of which had been mentionned in surveys). All molecules identified through surveys were tolerated in Cambodia, while 32 were not approved and 7 were not registered in the European Union (European Comission, n.d.). According to resellers, Glyphosate was the most comonly used chemical, used for rice, maize and mango with quantities ranging from 2 to 7 liter/ha/season. Other commonly used pesticides are: Hexaconazole, indoxacarb, chlorphenapyr, abamectin, difenoconazole and azoxystrobin.
- Out of 167 detected, 119 are not authorized in the EU and 10 banned in Cambodia. 40% detected are moderately hazardous and 9% highly harzardous. Pesticides accumulate locally and flushing during the dry season remains limited.

Figure 9. Occurence of chemical input use in the prek area (Source: adapted from Frick, 2020)



[2] Out of this, lab equipment in Cambodia could only detect 37

- The second agricultural system lies further away from the main rivers in 'low lying' areas that are frequently (if not always flooded) and locally called *boeung* (blue and purple area in Figure 3). In these boeung, short term HYV rice variety are cultivated, most often twice a year. Most of the production is exported as paddy to Vietnam where transformation take place. Profitability is low and negatively affected by low water availibility and high pumping cost.
- In addition to rice, though, these rice fields support productive and essential capture fishery production (with a production of 113 kg/ha as evaluated by Chheng et al., 2006 – this correspond to about half the added value of one rice cropping season).

Box 1: Challenges and innovative institutional arrangements in Kandal community fisheries

Fishery community (Fci) established in the early 2000s in Cambodia. Watershed in 2012/3 pre election when private lots 'tranferred' to FCi. Main objective is one of preservation of the resource. In the COSTEA study area, FCi established in 2013. The specificity of the FCi in Kandal is that they are exceptionnaly allowed to engage in commercial activities (according to many informants, this is because, if the fish is not caught in Cambodia, it goes to Vietnam). Fish biology and movement strongly influence fish catch and is itself strongly related to flood dynamics and notably change in water level. To minimize the time that members of the FCi spend at the collective fishing system while ensuring equity in distribution of benefit, the FC has developed a complex and innovative system of rotation and quota.

Between 2015 and 2020, the FC9 committee reported fish catch of 40 to 120 Tons a year (with an average of about 90 Tons), highly impacted by flood duration. In comparison, JICA (1998) reports fish catch of 116 Tons in 1995, under the lot management system. If population>18 years old and consumption of 42,7 kg/person is considered and assuming that people living in the 4 communes that span the lot source 75% of their fish there (the remaining in the Bassac and Mekong), fishing for self consumption in the area amount to 900 Tons (FC catch representing about 10% of fishing in the floodplain).

The FCi has difficulty enforcing conservation/preservation measures and controling fishing activities and is powerless vis-à-vis land reclamation that happens informally (given the public state land status of the area) but is somehow allowed by local authorities. Despite significant rolling funds, financial sustainability is not guaranteed given (1) declining fish catch in relation to land reclamation and changing flood patterns and (2) the fact that resources derived from the sale of fish are not re-invested in conservation/preservation measures and instead used for other purposes – including payments to media and officials.

Open capture fishery is central to the Cham communities (Muslim minority) living in the area. Already among the poorest peopl in the area, they are increasingly vulnerable due to shrinking open space for fishing in relation to land reclamation. Land reclamation means that land is flooded (hence provide a fishing ground) for a shorter time. In addition, cultivators tend to 'privatize' the open water areas in the vicinity of their land – stopping mobile fishermen to access these grounds. Some have turned towards agricultural labor.

Also a presence of Vietnamese minority, leaving in floating houses along the main river.

Towards Alternative Floodplain Governance: Articulating Research and (Water Infrastructure) Development Projects

- The COSTEA approach has been designed to inform prek rehabilitation activities planned under AFD development projects, first WASP and now WAT4CAM.
- The participatory approach used in the COSTEA project draws from a 3 year research project in the social science implemented by IRD, CIRAD, ISC and RUA.
- The objective of this past project and current COSTEA activity is (1) to provide a platform for users of the preks to express their views on the *prek mosaic* and (2) mainstream this local knowledge and concerns into projects' activities.

- **In terms of process, the COSTEA participatory approach aims at increasing the place given to prek users and local decision makers in project design and implementation.** This is based on the diagnosis that past and current development projects have mostly relied on expert (water) engineering expertise and that giving room to other actors and –possibly other priorities- may allow avoiding economically and environmentally costly mistakes (such as the collapse of sluice gates).

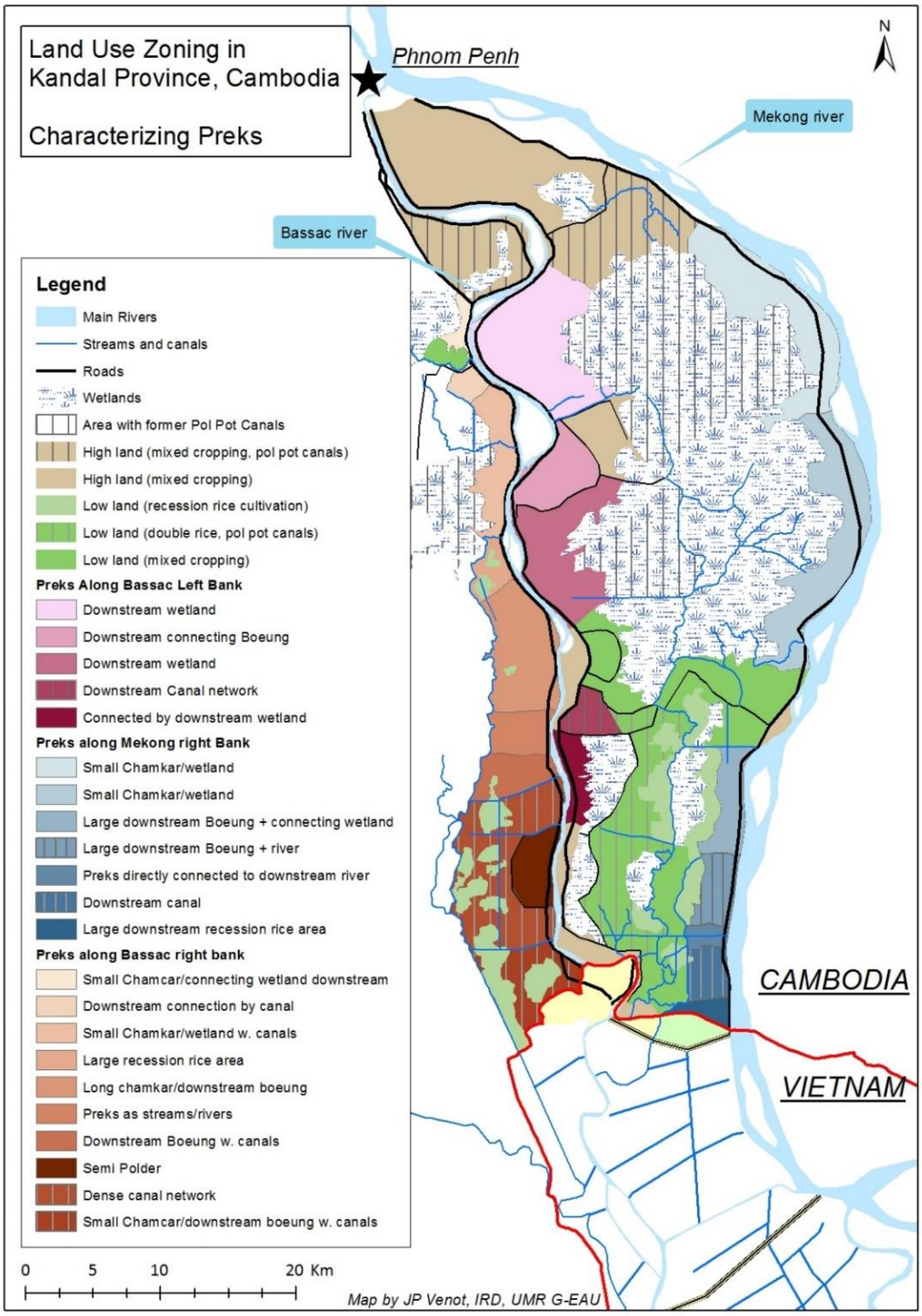
- **In terms of content, the COSTEA participatory approach differs from current prek rehabilitation activities as its 'entry point' is the socio-environment (*territoire* in French) in which preks are embedded rather than the preks themselves.** This implies an "open ended" discussion to ***first*** identify the purpose (*vocation,* in French) that a diversity of stakeholders assign to specific ***areas*** of the prek mosaic. ***Only then*** the role that prek rehabilitation can have in supporting this vision is tackled ; the type of rehabilitation and engineering interventions coming last while it tends to come first in curremt development projects (see an example of expert 'zoning' that may lead to a tailored approach to prek development in Figure 10: for instance, given the importance of capture fisheries, prek rehabilitation in the area between the Bassac and the floodplain could be envision to support sustainable capture fisheries as opposed to agricultural intensification – this would likely lead to very different water control infrastructure – if any).

- **Serious games are used because we hypothize that they allow more effective, active and meaningful participation from a variety stakeholders,** as compared to approaches such as rapid rural appraisal, focus group discussion, concertation that are more commonly used in development projects.

- A series of *serious games* representing the prek mosaic at different 'levels' has been designed and 4 participatory sessions have been implemented since December 2018. These sessions lasted 2 or 3 days, and each day, 10 to 20 people participated. Participants included farmers-cum-fishermen, village chiefs, local elected representatives, administrative and ministry staff at district and province level, ministry staff at national level, international development agents, and researchers.

- Together the sessions mostly served to acquire knowledge on the prek mosaic but also served as a 'proof of concept' to demonstrate that (1) *serious games* can be used to harness local knowledge that is valuable to 'development experts' and, because of that, (2) prek users should be given more room in project design and implementation.

Figure 10. representing the prek *land/waterscape* rather than the preks



- Currently, a tighter association with the WAT4CAM team is sought. In that perspective, the serious games developped can be used for two main purposes:
    - To contribute to the elaboration of the prek *master plan* under the WAT4CAM project. Using serious games that are generic/abstract enough (in the sense that they allow participants to represent a diversity of land/waterscapes) can support a **participatory zoning of the floodplain** and the identification of (general) **'guiding principles' for the development of preks.** The expected result is a the identification of key features of the landscape that lay the basis for a typology or areas and related interventions (depending on the ways these key features are combined). A series of participatory sessions organized on the

basis of a rough preliminary zoning (see for instance Figure 10) could be organized and their results combined to provide the basis for a master plan. Such activity will lead to the elaboration of a 'vision' for the future of the prek mosaic as opposed to yielding a list of possible practical/tangible intervention.

  - They can also be tailored to represent a *specific area* and *specific engineering/social water management* options identified by the WAT4CAM project team. The games can then be used to discuss and test the acceptability of these options with prek users.[3] This only makes sense if the "project experts" **are willing and able to modify the options** presented on the basis of feedback from prek users. If well planned and implemented, such participatory sessions are likely to provide meaninful insights regarding the acceptability of options proposed by experts (as opposed to a 'mere validation' obtained in a broad concertation during which the implications of different options are often not clearly spelled out). Rather than focusing on the technical options per se, the participatory sessions should focus on the implication of these technical options and make explicit their uncertainty (for instance in terms of water availability or yield gains)

There are several inter-related challenges for a research-led participatory approach such as the one implemented in the COSTEA to effectively inform development projects activities. These challenges relate to (1) different views in relation to expert knowledge, (2) the type of tools develop and the objectives assigned to it in terms of knowledge generation and (2) the daily realities of development projects implementation:

- In relation to (expert) knowledge:
  - Participatory approaches such as the one adopted in the COSTEA question the primacy given to expert knowledge (researcher's included) and require a willingness to question such knowledge. To speak plainly, it requires from the expert that s/he recognizes that s/he may not know "what's best for farmers" and a willingness to question his/her own assumptions.
  - Related to this, participatory approaches such as the one adopted in the COSTEA hinge on recognizing and making explicit that expert/development agents only have partial knowledge. Crucially, this means that there is considerable uncertainty regarding the consequences of the intervention proposed. Such acknowledgment of the limits of expert/scientific knowledge can take other stakeholders aback as it is not commonly made explicit.

- The type of tools:
  - Uneasiness and unfamiliarity with tools that purposefully and visibly simplify reality (in contrast to e.g. computerized hydrological models) often leads to disqualifying these as being *not serious*, which then deligitimize their outcomes.
  - Serious games hinge on the creation of a distance to reality (often achieved through simplification, abstraction, genericity). In a sense, they are exercises in "speculative empiricism", mostly concerned with identifying/exploring "possibilities". On the other hand, development project staff main concern (and what is expected from them) may be to identify specific solutions to very

[3] Ideally, this should take place *after* prek users have had the opportunity to present how they wish to see the area in which they live evolve – and options designed on this basis.

tangible problems/issues. It is crucial to make these differences in orientation explicit and to identify ways of articulating them. This is particularly important as the identification of possibilities or potentials – though very conceptual and theoretical- can actually lead to questioning the very principles that underpinned project design (such as – in our case- the relevance of building water control infrastructure)

- In practical terms:
    - Difference in timeline (adaptive ad-hoc schedule for research and strict adherence to a pre-defined schedule for development project), which means the research team might not be available when most relevant.
    - Development agents are generally not familiar to the type of approaches developed in the COSTEA project. These often require 'going the extra mile' and do not allow reaching as many people – though maybe more meaningfully- as compared to other consultation/rapid rural appraisal techniques more commonly used in the context of development projects. As such, they may be at loggerheads with the terms of reference of development agents.
    - Participatory activities may lead to questioning the relevance of options pursued by the technical teams, meaning the project design should be adaptive enough so that these insights are taken into consideration and initial plans can be revised. This notably require timely articulation of participatory and projects activities.

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Les documents sont disponibles au lien suivant (lien accessible après autorisation): https://www.dropbox.com/sh/s4uhn8slzynoj1j/AAD9YM_AZ9c6CN6y_uxyG3lwa?dl=0

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