A qualitative assessment of climate change impacts on the stability of small tidal inlets via schematised numerical modelling

Duong, Trang; Ranasinghe, R.W.M.R.J.B.; Luijendijk, Arjen; Walstra, Dirk Jan; Roelvink, Dano

Publication date
2014

Document Version
Final published version

Citation (APA)
Duong, T., Ranasinghe, R. W. M. R. J. B., Luijendijk, A., Walstra, D. J., & Roelvink, D. (2014). *A qualitative assessment of climate change impacts on the stability of small tidal inlets via schematised numerical modelling*. Poster session presented at 34th International Conference on Coastal Engineering, Seoul, Korea, Republic of.

ICCE2014 Seoul, Korea June 15-20 2014

UNESCO-IHE
Institute for Water Education

Deltares
Enabling Delta Life

A QUALITATIVE ASSESSMENT OF CLIMATE CHANGE IMPACTS ON THE STABILITY OF SMALL TIDAL INLETS VIA SCHEMATISED NUMERICAL MODELLING

Trang Duong*, Roshanka Ranasinghe, Arjen Luijendijk, Dirk-Jan Walstra and Dano Roelvink

(*t.duong@unesco-ihe.org)

Research Questions:

1. Are currently available predictive tools capable of simulating CC impacts on more commonly found small tidal inlet (STI) systems?

2. Nature and magnitude of full range potential CC impacts on these systems?

❖ Modelling approach:

Present condition simulation (PS)	Climate Change simulations (CS)
- schematised monthly averaged wave and riverflow forcing; simplified tidal forcing, representing contemporary conditions at the study areas.	- Varying MSL (i.e. SLR), wave, riverflow; **in-isolation (G1)** and **in combination (G2).** + SLR (by 2100): 1m + H_s, θ and R vary (from PS values) - Simulation duration: same as PS - Basin infilling included in SLR simulations

Methods:

❖ Series of strategic **idealised model applications**, using **Delft3D** .

❖ Schematised inlet/forcing conditions representing 3 main inlet morphodynamic characteristics:

Type 1: Permanently open, locationally stable inlet

Type 2: Permanently open, alongshore migrating inlet

Type 3: Seasonally/Intermittently open, locationally stable inlet

❖ Representative sites: Type 1 – Negombo lagoon; Type 2 – Kalutara lagoon; Type 3 – Maha Oya river (Southwest coast of Sri Lanka).

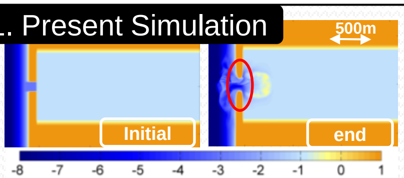
Model Results: Inlet stability indicator: r=P/Mtot

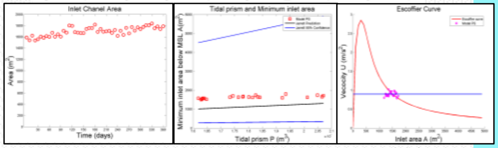
(Bruun, 1978: Mtot=annual littoral drift (m³/year), P= tidal prism (m³))

$r=P/M_{tot}$	> 150	100 – 150	50 – 100	20 – 50	< 20
Bruun Classifications	Good	Fair	Fair to poor	Poor	Unstable

Type 1: Stable Inlet

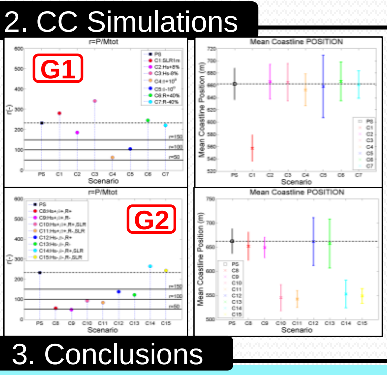
1. Present Simulation





- **Inlet locationally, cross-sectionally stable, r=233 (consistent with Bruun criteria)**
- **Model results agree with Jarrett 1976 AP relationship and Escoffier curve**

2. CC Simulations



3. Conclusions

➢ **Type 1** inlet **does not change** its behavior significantly *(**does not change type**)* due to CC driven variations in system forcing but its stability **can change** significantly *(r changes classes in Bruun criteria: from **good** to **fair** or **fair to poor**; but **not to the lower, more unstable** classifications, r still always > 50).*

➢ Responses of inlet to the different CC forcing scenarios:

○ A change in **wave direction (θ)** **alone** (northerly/southerly shift of direction +10/-10º), both leading to an **enhancement of littoral drift,** can have a significant impact on inlet stability (r changes significantly from good (r>150) to fair (100-150) or fair to poor (50-100) class).

○ Changes in **riverflow** (±40%), $\mathbf{H_s}$(±8%) or **SLR** **alone** have insignificant impact on inlet stability (r always >150, inlet in “good” Bruun classification).

○ **Enhancement of littoral drift** by (Hs+8%,θ+10º or Hs-8%,θ-10º) can result in r values from >150 to 50 (but not below 50).

○ Scenarios with **SLR** or **higher riverflow (R)** generally increases r.

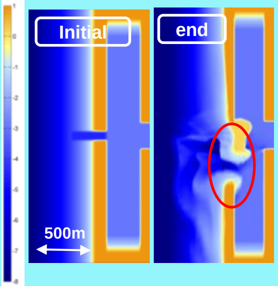
○ **SLR of 1m** results in significant mean **coastline recession** (up to ~120m). **Other CC** driven changes in system forcing **do not** result in significant coastline recession/progradation.

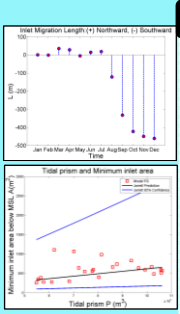
○ **Coastline variability** (spatial) is maximum when **θ** becomes more southerly (std of ~100m).

➢ Inlet **does not change type** in all tested CC scenarios, implying that even under the **most extreme** projected CC driven variations in forcing, Type 1 inlet **will not change** its general behavior.

Type 2: Migrating inlet

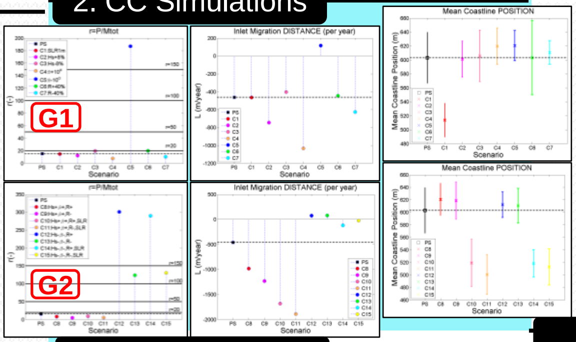
1. Present Simulation





- **Inlet migrates 460m Southward (in one year), r=16 (consistent with Bruun criteria, unstable inlet)**
- **Model results agree with Jarrett 1976 AP relationship**

2. CC Simulations



3. Conclusions

➢ **Type 2** inlet **can change** its behavior significantly due to CC driven variations in system forcing *(i.e. inlet can change to **Type 1 stable** inlet, r changing from **unstable** to **fair** or **good** in Bruun criteria).*

➢ Inlet responses to the various CC forcing scenarios show:

○ A change in **wave direction** by a southerly shift **(θ-10º)** **alone**, leading to a **reduction of littoral drift** can have a significant impact on inlet behavior (r can change significantly from 16 to >150, changing type from unstable to a **Type 1 stable inlet**).

○ Changes in **riverflow** (±40%), $\mathbf{H_s}$(±8%), northerly shift of wave direction (**θ+10º**) or **SLR** **alone** have insignificant impact, i.e. inlet does not change type (r varies in the range (5-20)) .

○ **Enhancement of littoral drift** (Hs+8% and θ+10º) does not change inlet behavior (r reduces slightly but in the range (5-10)). When **SLR** is combined with **enhanced littoral drift,** inlet migration is maximum.

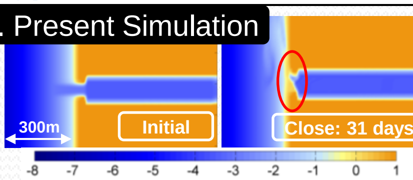
○ When Hs and θ **both** change such that **littoral drift is reduced** (Hs-8% and θ-10º) inlet changes type to **Type 1 stable inlet** (r increases to >150).

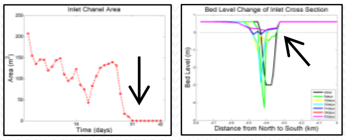
○ **SLR of 1m** results in significant mean **coastline recession** (up to ~100m in C11). **Other CC** driven changes in system forcing **do not** result in significant coastline recession/progradation.

○ **Coastline variability** (spatial) is maximum when **Riverflow** changes (std of ~100m)

Type 3: Intermittently Closing Inlet

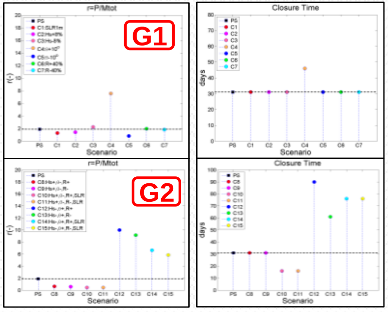
1. Present Simulation





- **Inlet completely closes when riverflow is small (after 31days), r=2 (consistent with Bruun criteria, unstable inlet).**

2. CC Simulations



3. Conclusions

➢ **Type 3** inlet **does not** change its behavior significantly due to any CC driven variations in system forcing *(i.e. inlet **does not change type**, inlet always closes, r always <20 in unstable Bruun category).*

➢ However, under individual CC forcing scenarios, the inlet response varies:

○ **Reduction of littoral drift** (by more northerly wave direction **θ+10º**) **alone** results in a significantly slower inlet closure (time taken to close is 46days, 48.4% > than PS).

○ Changes in **riverflow** (±40%) or $\mathbf{H_s}$(±8%) or **enhancement of littoral drift** (southerly shift of wave direction **θ-10º**) or **SLR** **alone** seems to not affect inlet behavior significantly (i.e. time taken to close more or less the same as present situation PS).

○ When H_s and θ **both** change such that **littoral drift is enhanced** (H_s+8% and θ-10º) inlet behavior remains unchanged. **But** When **SLR** is combined with **enhancement of littoral drift,** inlet closes faster (16days, % change in closure time =50 compared to PS) .

○ Regardless of whether SLR is present or not, inlet **closes slower** (% change in closure time maximum 200 compared to PS) when H_s and θ **both** change such that **littoral drift is reduced** (H_s-8% and θ+10º).

➢ Inlet **does close** in all tested CC scenarios, implying that even under the **most extreme** projected CC driven variations in forcing, general behavior of intermittent closure **will not change** at Type 3 inlets.