A new cost-performance grid to compare different flood modelling approaches – Supplementary Material

Rouya Hdeib[a,b], Roger Moussa[c], François Colin[b,d], and Chadi Abdallah[a]*

[a]*CNRS-RS, Lebanese National Council for Scientific Research, Remote Sensing Center, Beirut, Lebanon.*
[b]*UMR LISAH, Univ. Montpellier, Montpellier SupAgro, Montpellier, France.*
[c]*UMR LISAH, Univ Montpellier, INRAE, IRD, Montpellier SupAgro, Montpellier, France.*
[d]*UMR G-EAU, Univ. Montpellier, Montpellier SupAgro, Montpellier.*

*corresponding author: Chadi Abdallah, chadi@cnrs.edu.lb

This supplementary material presents the cost-performance grid and the detailed results of the evaluation for the selected study cases. We also present a general layout of the designed online survey to collect information on more modeling approaches.

Table S1 Description of the selected flood modeling study cases for cost-performance analysis.

Study case ID	Study case	Study Site/ Country	Area/ Length	Models	Reference for models used	Modeling approach	Type of output
1	Hdeib et al. (2018)	Awali River Basin, Lebanon	301 km^2	HEC-HMS; HEC-RAS	USACE (2000, 2016)	Coupling	Flood inundation map
2	Abdallah et al. (2013)	Awali River Basin, Lebanon	301 km^2	Empirical +HEC-RAS	Manning's, USACE (2016)	Empirical	Flood inundation map (water levels)
3	Knebl et al. (2005)	San Antonio River Basin, Central Texas, USA	10 000 km^2	HEC-HMS; HEC-RAS	USACE (2000, 2016)	Coupling	Flood inundation map
4	Neal et al. (2012)	Niger river, Mali.	210 389 km^2	Sub-Grid LISFLOOD-FP	Neal et al. (2012)	Hydraulic 1D/2D	Flood inundation map
5	Moussa (1991)	Gardon Basin, France	542 km^2	ModSpa	Moussa (1991)	Hydrologic	Flow hydrograph at outlet
6	Coustau et al. (2012)	Lez catchment, France	114 km^2	SCS-LR (Linear Lag and Route)	Coustau et al. (2012)	Hydrologic	Flow hydrograph at outlet
7	Koutroulis and Tsanis (2010)	Giofiros basin, Greece	158 km^2	HEC-HMS, HEC-RAS	USACE (2000, 2016)	Coupling	Flow hydrograph and water level
8	Fuentes-Andino et al. (2017)	Floodplain of Tegucigalpa, Honduras	811 km^2	TOPMODEL, LISFLOOD-FP	Beven and Kirkby (1979), Bates and De Roo (2000)	Coupling	Flood inundation map
9	Montanari et al. (2009)	Alzette River (Grand Duchy, Luxembourg)	356 km^2	hydrologic Nash (1960), HEC-RAS	Nash (1960), USACE (2016)	Coupling	Flood inundation map
10	Liu et al. (2005)	Upper Xixian catchment in Huaihe River, China	10 000 km^2	TOPKAPI model	Ciarapica and Todini (2002)	Hydrologic	Runoff per cell
11	Siddiqui et al. (2018)	Jhelum and Chenab river basins in Punjab, Pakistan	10 000 km^2	2D rainfall-runoff- inundation (RRI)	Sayama et al. (2012)	Coupling	Flood inundation map
12	Horritt and Bates (2002)	River Severn, UK	60 km reach	HEC-RAS	USACE (2016)	Hydraulic 1D	Flood inundation map
13	Horritt and Bates (2002)	River Severn, UK	60 km reach	LISFLOOD-FP	Bates and De Roo (2000)	Hydraulic 2D	Flood inundation map
14	Horritt and Bates (2002)	River Severn, UK	60 km reach	TELEMAC-2D	Galland et al. (1991)	Hydraulic 2D	Flood inundation map
15	Marks and Bates (2000)	River Stour in Dorset, UK	12 km reach	TELEMAC-2D	Galland et al. (1991)	Hydraulic 2D	Flood inundation map
16	Nguyen and Bouvier (2019)	Real Collobrier catchment, France (at Pont de Fer)	70 km^2	SCS-LR (Linear Lag &Route)	Coustau et al., 2012	Hydrologic	Flow hydrograph at outlet
17	Samela et al. (2018)	Romania (Danube River)	238 000 km^2	Geomorphic Flood Area (GFA)	Samela, et al. (2017)	Geomorphic	Flood prone area map 30m
18	Samela et al. (2017)	Ohio River basin, (calibration) Continental U.S. (application)	529 000 km^2	Geomorphic classifiers, GFI	Samela, et al. (2017)	Geomorphic	Flood prone area map 90m

Table S2 Detailed results of the cost-performance calculation for Application 1 for 18 selected study cases in literature based on the proposed cost-performance grid. Scores are evaluated based on a linear scale of five levels from 1 to 5. Weights and global weights are evaluated based on three levels 1, 2, and 3. * $C_{D\,[1]}$: the cost of data (dimensionless), $C_{M\,[1]}$: the cost of models (dimensionless), $C_{T\,[1]}$: the total cost of the modelling approach (dimensionless), $P_{M[1]}$: Performance level of the modelling approach (dimensionless).

Study case ID	$C_{D\,[1]}$*	$C_{M\,[1]}$*	$C_{T\,[1]}$*	$P_{M\,[1]}$*
1	0.29	0.51	0.43	0.64
2	0.11	0.31	0.19	0.33
3	0.33	0.46	0.46	0.60
4	0.18	0.31	0.27	0.80
5	0.24	0.63	0.42	0.38
6	0.23	0.34	0.33	0.51
7	0.22	0.55	0.37	0.69
8	0.24	0.69	0.43	0.64
9	0.24	0.47	0.37	0.82
10	0.19	0.44	0.31	0.49
11	0.24	0.63	0.42	0.63
12	0.22	0.20	0.27	0.61
13	0.22	0.22	0.28	0.60
14	0.22	0.25	0.29	0.61
15	0.20	0.24	0.26	0.58
16	0.23	0.33	0.32	0.51
17	0.06	0.44	0.17	0.33
18	0.17	0.42	0.29	0.40

Table S3. Detailed results of the cost-performance calculation for Application 2 for 18 selected study cases in literature based on sensitivity analysis on the weights of the proposed cost-performance grid. Scores are evaluated based on a scale of five levels from 1 to 5. All weights and global weights are considered 1. * $C_{D\,[1]}$: the cost of data (dimensionless), $C_{M\,[1]}$: the cost of models (dimensionless), $C_{T\,[1]}$: the total cost of the modelling approach (dimensionless), $P_{M[1]}$: Performance level of the modelling approach (dimensionless).

Study case ID	$C_{D\,[1]}$*	$C_{M\,[1]}$*	$C_{T\,[1]}$*	$P_{M\,[1]}$*
1	0.24	0.51	0.45	0.53
2	0.09	0.31	0.22	0.20
3	0.28	0.40	0.45	0.47
4	0.16	0.26	0.27	0.68
5	0.19	0.63	0.45	0.33
6	0.17	0.35	0.32	0.47
7	0.19	0.54	0.42	0.63
8	0.20	0.63	0.47	0.50
9	0.21	0.48	0.42	0.77
10	0.14	0.47	0.34	0.40
11	0.22	0.61	0.48	0.52
12	0.16	0.18	0.23	0.52
13	0.16	0.19	0.24	0.50
14	0.16	0.21	0.24	0.52
15	0.10	0.20	0.19	0.50
16	0.16	0.34	0.30	0.47
17	0.08	0.42	0.26	0.20
18	0.13	0.40	0.30	0.27

Table S4. Detailed results of the cost-performance calculation for eleven selected study cases in literature based on sensitivity analysis on the scores of the proposed cost-performance grid. Scores are evaluated based on a log scale of five levels from 1 to 10 000. Weights and global weights are evaluated based on three levels 1, 2, and 3. * $C_{D[1]}$: the cost of data (dimensionless), $C_{M[1]}$: the cost of models (dimensionless), $C_{T[1]}$: the total cost of the modelling approach (dimensionless), $P_{M[1]}$: Performance level of the modelling approach (dimensionless).

Study case ID	$C_{D[1]}$*	$C_{M[1]}$*	$C_{T[1]}$*	$P_{M[1]}$*
1	0.10	0.16	0.14	0.35
2	0.00	0.12	0.03	0.03
3	0.18	0.19	0.23	0.34
4	0.03	0.02	0.03	0.57
5	0.13	0.35	0.22	0.00
6	0.18	0.16	0.22	0.23
7	0.05	0.18	0.10	0.18
8	0.11	0.38	0.22	0.36
9	0.12	0.21	0.18	0.38
10	0.04	0.33	0.13	0.04
11	0.09	0.30	0.17	0.36
12	0.10	0.12	0.13	0.34
13	0.10	0.04	0.11	0.34
14	0.10	0.13	0.13	0.34
15	0.10	0.13	0.13	0.36
16	0.13	0.16	0.18	0.23
17	0.00	0.15	0.05	0.03
18	0.03	0.09	0.05	0.03

Table S5 Detailed cost-performance evaluation. *Des.: Description, S: score, W: weight.

Hydrological Model Dataset																	
Hydrologic Data (water level, flow…)															Cost of hydrologic data		Max. Cost
Study case ID	Type	No. of variables	Duration			Spatial resolution			Temporal resolution			Continuity					
			Des.*	S*	W	Des.	S	W*	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	water levels	1	10 years	3	2	point data/ two gauges	1	3	hourly	5	3	many gaps	1	1	2	50.00	90.00
2	Discharge	1	10 years	3	2	point data/ one gauge	1	3	Daily	3	3	many gaps	1	1	2	38.00	90.00
3	Stream flow and water level	1	1 month	1	2	12 USGS gauges	3	3	hourly	5	3	time series	5	1	2	62.00	90.00
4	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
5	Discharge	1	10 years	3	2	2 gauge stations	2	3	hourly	5	3	time series	5	1	2	64.00	90.00
6	Discharge	1	20 years	4	2	one gauge	1	3	hourly	5	3	time series	5	1	2	62.00	90.00
7	Discharge	1	10 years	3	2	one gauge	1	3	hourly	5	3	some gaps	4	1	2	56.00	90.00
8	Peak flow or time of peak estimation	1	1 day	1	2	@ 7 locations	2	3	one estimation	1	3	many gaps	1	1	2	24.00	90.00
9	water level/flow	1	1 month	1	2	6 stream gauges	3	3	15 min	5	3	few gaps	4	1	2	42.00	90.00
10	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
11	Discharge	1	1 month	1	2	4 river gauges + barrages & dams	3	3	6-hourly	3.5	3	time series	5	1	2	53.00	90.00
12	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
13	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
14	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
15	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
16	Discharge	1	38 years	4	2	one gauge	1	3	30 min	5	3	time series	5	1	2	62.00	90.00
17	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
18	Not applicable	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00

Hydrological Model Dataset																	
Hydrometeorologic data (rainfall, snow, temp…)															Cost of hydrometeorologic data		Max. Cost
Study case ID	Type	No. of variables	Duration			Spatial resolution			Temporal resolution			Continuity					
			Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	Rainfall	1	10 years	3	2	multiple points low density (7 gauges by Theisen)	2	3	daily	3	3	some gaps	3	1	2	48.00	90.00
2	No rainfall	1	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
3	Rainfall	1	June 30–July 9, 2002 (10 days)	1	2	Radar (NEXRAD) 4x4 km	5	3	hourly	5	3	continuous series	5	1	2	74.00	90.00
4	Rainfall ignored	1	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
5	Rainfall	1	10 years	3	2	7 gauges	3	3	hourly	5	3	time series	5	1	2	70.00	90.00
6	Rainfall	1	14 years	3	2	4 gauges/ Radar 1 km2	5	3	hourly	5	3	time series	5	1	2	82.00	90.00
7	Rainfall	1	10 years	3	2	3 to 4 gauges by Theisen	2	3	daily/hourly	3.5	3	some gaps	4	1	2	53.00	90.00
8	rainfall	1	2 days	1	2	2 gauges (average uniformly distributed)	2	3	hourly	5	3	time series	5	1	2	56.00	90.00
9	rainfall	1	1 month	1	2	1 gauge (uniformly distributed)	1	3	15 min	5	3	time series	5	1	2	50.00	90.00
10	rainfall + evaporation	2	1 year and 6 months	2	2	24 rain gauges + 1 evaporation station	2	3	6-hour	4	3	time series	5	1	2	108.00	90.00
11	rainfall (GSMap-NRT), daily 25 stations	1	1 month (1-30 Sept 2014)	1	2	satellite precipitation, spatial 0.1degree	4	3	hourly	5	3	time series	5	1	2	68.00	90.00
12	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
13	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
14	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
15	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
16	Rainfall	1	38 years	4	2	17 rain gauges	3	3	30 min	5	3	time series	5	1	2	74.00	90.00
17	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00
18	-	-	-	0	2	-	0	3	-	0	3	-	0	1	2	0.00	90.00

Hydrological Model Dataset												
Geomorphic Data										Cost of geomorphic data		Max. Cost
Study case ID	Type			Resolution			Availability					
	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	DEM, cartographic	1	2	10	4	3	available @ CNRS	1	1	1	15.00	30.00
2	No DEM	0	2	-	0	3	-	0	1	1	0.00	30.00
3	USGS NED online DEM's	3	2	30 m (tuned with 10 m)	4.5	3	open source	1	1	1	20.50	30.00
4	Not applicable	0	2	-	0	3	-	0	1	1	0.00	30.00
5	DEM, cartographic	1	2	250m	1	3	developed	3	1	1	8.00	30.00
6	not applicable	0	2	-	0	3	-	0	1	1	0.00	30.00
7	available DTM	1	2	1/10 000	2	3	available	1	1	1	9.00	30.00
8	SRTM DEM	2	2	90 m	2	3	open source	1	1	1	11.00	30.00
9	no geomorphic data required	0	2	-	0	3	-	0	1	1	0.00	30.00
10	GTOPO30 public domain DEM, USGS	1	2	1000 m	1	3	open source	1	1	1	6.00	30.00
11	Hydrosheds DEM	2	2	2 km	1	2	open source	1	2	2	8.00	30.00
12	-	0	2	-	0	2	-	0	2	2	0.00	30.00
13	-	0	2	-	0	2	-	0	2	2	0.00	30.00
14	-	0	2	-	0	2	-	0	2	2	0.00	30.00
15	-	0	2	-	0	2	-	0	2	2	0.00	30.00
16	-	0	2	-	0	2	-	0	2	2	0.00	30.00
17	SRTM 1 Arc-Second	2	2	30 m	4	3	open source	1	1	1	17.00	30.00
18	Hydrosheds DEM-Void, DEM-CON	2	2	90 m	2	3	open source	1	1	1	11.00	30.00

Hydrological Model Dataset															
Geographical and background data											Cost of geographical data		Max. Cost	Total cost of Hydrological Data	Max. cost of Hydrological Data
Study case ID	Type	Number			Scale/Resolution			Availability							
	Des.	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total		
1	LUC, soil, geology	3	2	3	Moderate scale (1:20 000)	3	2	developed/ available	1	1	1	13.00	30.00	126.00	240.00
2	No LUC	-	0	3	-	0	2	-	0	1	1	0.00	30.00	38.00	240.00
3	LUC (NLCD92), soil (STATSGO)	2	2	3	30 m; 1/250 000;	4	2	available open source	1	1	1	15.00	30.00	171.50	240.00
4	Not applicable	-	0	3	-	0	2	-	0	1	1	0.00	30.00	0.00	240.00
5	LUC, soil, Geo	3	2	3	approximations	3	2	available	1	1	1	13.00	30.00	155.00	240.00
6	not applicable	-	0	3	-	0	2	-	0	1	1	0.00	30.00	144.00	240.00
7	LUC, soil, geology	3	2	3	no information	3	2	provided by authority	1	1	1	13.00	30.00	131.00	240.00
8	Uniform LUC and Geology	2	1	3	uniform	1	2	available	1	1	1	6.00	30.00	97.00	240.00
9	no geographical data required	-	0	3	-	0	2	-	0	1	1	0.00	30.00	92.00	240.00
10	Soil texture (global soils dataset, Reynolds et al. (1999)), UMD land cover world map	2	1	3	10 km, 1 km	1	2	available open source	1	1	1	6.00	30.00	120.00	240.00
11	Globe landcover 30-m (GLC30m), FAO soil database, USDA Green-Ampt model parameters	3	2	3	LUC (30 m), no information on others	3	2	open source	1	1	1	13.00	30.00	142.00	240.00
12	reach maps for the hydraulic model	1	1	3	1/25 000	1	2	available	1	1	1	6.00	30.00	6.00	240.00
13	reach maps for the hydraulic model	1	1	3	1/25 000	1	2	available	1	1	1	6.00	30.00	6.00	240.00
14	reach maps for the hydraulic model	1	1	3	1/25 000	1	2	available	1	1	1	6.00	30.00	6.00	240.00
15	-	-	0	3	-	0	2	-	0	1	1	0.00	30.00	0.00	240.00
16	LUC, soil, geology, SIM model water content	3	2	3	soil 1 km, water content 8km	1	2	provided by relevant authority	1	1	1	9.00	30.00	145.00	240.00
17	pan-European flood hazard map (Alfieri et al. 2014)	1	1	3	100 m	4	2	available	1	1	1	12.00	30.00	29.00	240.00
18	National Flood Hazard Layer (NFHL) 2015 (FEMA)	1	1	3	no information	2	2	available	1	1	1	8.00	30.00	19.00	240.00

Hydraulic Model Dataset												
Topographic Data										Cost of topographic data		Max. Cost
Study case ID	Type			Resolution			Availability					
	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	DEM, drone	3	2	10 cm	5	3	developed	3	1	2	48.00	60.00
2	DEM available @ CNRS	1	2	10 m	3	3	available @ CNRS	1	1	2	24.00	60.00
3	same available DEM + cross section surveys	4	2	few cross sections >100 m spacing	1	3	developed	3	1	2	28.00	60.00
4	DEM, SRTM	3	2	905 m	1	3	open source	1	1	2	20.00	60.00
5	no hydraulic model	0	2	-	0	3	-	0	1	2	0.00	60.00
6	no hydraulic model	0	2	-	0	3	-	0	1	2	0.00	60.00
7	no information/ same available DTM	0	2	-	0	3	-	0	1	2	0.00	60.00
8	LIDAR survey DTM, vertical accuracy 0.14m + cross section surveys	4	2	15 cm	5	3	available	1	1	2	48.00	60.00
9	LIDAR DEM + 200 bathymetric cross sections	4	2	2 m	4	3	available	1	1	2	42.00	60.00
10	no hydraulic model	0	2	-	0	3	-	0	1	2	0.00	60.00
11	Same DEM	0	2	-	0	3	-	0	1	2	0.00	60.00
12	LIDAR DEM (15 cm accuracy) + 19 ground survey sections	0	2	50 m	2	3	developed	3	1	2	34.00	60.00
13	LIDAR DEM (15 cm accuracy) + 19 ground survey sections	4	2	50 m	2	3	developed	3	1	2	34.00	60.00
14	LIDAR DEM (15 cm accuracy) + 19 ground survey sections	4	2	50 m	2	3	developed	3	1	2	34.00	60.00
15	LIDAR DEM (15 cm accuracy)+25 survey x-sec	3	2	4 m	4	3	provided but fine tuned	2	1	2	40.00	60.00
16	no hydraulic model	0	2	-	0	3	-	0	1	2	0.00	60.00
17	-	0	2	-	0	3	-	0	1	2	0.00	60.00
18	-	0	2	-	0	3	-	0	1	2	0.00	60.00

Hydraulic Model Dataset																
Time series of bulk flow rates & stage data														Cost of flow and stage data		Max. Cost
Study case ID	Type	Duration			Spatial resolution			Temporal resolution			Continuity					
	Des.	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	Input from hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
2	Input from hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
3	Input from hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
4	Discharge	2002-2009	3	2	3 gauge stations	2	3	daily	3	3	time series	5	1	3	78.00	135.00
5	no hydraulic model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
6	no hydraulic model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
7	Input form hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
8	Input from hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
9	Input from hydrological model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
10	no hydraulic model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
11	Same input discharge	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
12	upstream hydrograph +measured elevation @ downstream	2 events	2	2	2 stage recorders	2	3	hourly	5	3	time series	5	1	3	90.00	135.00
13	upstream hydrograph +measured elevation @ downstream	2 events	2	2	2 stage recorders	2	3	hourly	5	3	time series	5	1	3	90.00	135.00
14	upstream hydrograph +measured elevation @ downstream	2 events	2	2	2 stage recorders	2	3	hourly	5	3	time series	5	1	3	90.00	135.00
15	upstream and downstream hydrograph	(62 h) 1 event	1	2	2 flow gauges	2	3	discretized into 4 s	5	3	time series	5	1	3	84.00	135.00
16	no hydraulic model	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
17	-	-	0	2	-	0	3	-	0	3	-	0	1	3	0.00	135.00
18	streamflow observations for calibrating b and n	80 years	4	2	486 gauge stations	3	3	no information	2	3	no information (USGS)	5	1	3	84.00	135.00

Hydraulic Model Dataset							
Roughness data					Cost of roughness		Max. Cost
Study case ID	Type	Type/ Resolution					
	Des.	Des.	S	W	Sub-category weight	Total	Total
1	based on LUC	spatial 1/20 000	3	1	1	3	5
2	based on LUC	spatial 1/20 000	3	1	1	3	5
3	based on LUC	30 m	4	1	1	4	5
4	estimated based on LUC	spatial	3	1	1	3	5
5	not applicable	-	0	1	1	0	5
6	not applicable	-	0	1	1	0	5
7	no information	estimated	3	1	1	3	5
8	uniform for reach and floodplain along all reaches	estimated	1	1	1	1	5
9	uniform for reach and floodplain	estimated	1	1	1	1	5
10	-	-	0	1	1	0	5
11	National landcover dataset NLCD	estimated global manning's for channel	2	1	1	2	5
12	uniform for reach and floodplain	estimated then calibrated	1	1	1	1	5
13	uniform for reach and floodplain	estimated then calibrated	1	1	1	1	5
14	uniform for reach and floodplain	estimated then calibrated	1	1	1	1	5
15	uniform for reach and floodplain	estimated then calibrated	1	1	1	1	5
16	not applicable	-	0	1	1	0	5
17	not applicable	-	0	1	1	0	5
18	not applicable	-	0	1	1	0	5

Hydraulic Model Dataset											
Data for model calibration/validation							Cost of calibration/ validation data		Max. cost	Total cost of hydraulic data	Max. cost of hydraulic data
Study case ID	flood extent mapping			water stage retrieval							
	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total		
1	+ social media inf., pictures/ witnesses	1	1	27 post-events of max. water marks	2	1	2	6	20	57.00	220.00
2	+ social media inf., pictures/ witnesses	1	1	post-event at gauge	1	1	2	4	20	31.00	220.00
3	Landsat TM images	3	1	no information	0	1	2	6	20	38.00	220.00
4	24 Landsat TM5 images (free images)	3	1	ICESat laser altimeter 127 obs. @ 18 locations (free images)	4	1	2	14	20	115.00	220.00
5	-	0	1	-	0	1	2	0	20	0.00	220.00
6	not applicable	0	1	12 piezometers at hourly step (2000,2008)	3	1	2	6	20	6.00	220.00
7	+ cross section and local witnesses	1	1	filed measurements @ gauge	1.5	1	2	5	20	8.00	220.00
8	field witnesses + previous deterministic rainfall-runoff and hydraulic modeling	2	1	around 100 post event measurements @ 100 m spacing	2	1	2	8	20	57.00	220.00
9	84 flood extent marks by GPS + 2 SAR images	4	1	max water level at 7 points by theodolite + 2 SAR images (ERS-2 & ENVISAT)	4	1	2	16	20	59.00	220.00
10	-	0	1	-	0	1	2	0	20	0.00	220.00
11	MODIS imagery	3	1	gauged river discharge at 4 gauges	2	1	2	10	20	12.00	220.00
12	2 SAR images	3	1	measured travel time for calibration at downstream boundary condition	1	1	2	8	20	133.00	220.00
13	2 SAR images	3	1	measured travel time for calibration at downstream boundary condition	1	1	2	8	20	133.00	220.00
14	2 SAR images	3	1	measured travel time for calibration at downstream boundary condition	1	1	2	8	20	133.00	220.00
15	comparison between standard DEM and LIDAR	0	1	-	0	1	2	0	20	125.00	220.00
16	not applicable	0	1	-	0	1	2	0	20	0.00	220.00
17	national flood hazard map	3	1	-	0	1	2	6	20	6.00	220.00
18	national flood hazard map and hydrologic-hydraulic modeling in some regions	3	1	-	0	1	2	6	20	90.00	220.00

Hydrological model																									
Type of hydrological model																							Cost of hydrological model type		Max. Cost
ID	Type	Spatial scale			Temporal scale			Nb. of events/ Duration			Nature of basic algorithms			Spatial representation			Computational time step			flow processes represented					
	Des.	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	HEC-HMS (SCS-CN +SCS-UH)	Basin	4	1	event-based	1	2	12	3	1	conceptual	4	3	semi-distributed	3	3	30 min	5	1	overland & channel flow	3	1	1	38.00	60.00
2	empirical	Basin	4	1	event-based	1	2	1	1	1	empirical	1	3	lumped	1	3	coarse	1	1	overland flow	1	1	1	15.00	60.00
3	HEC-HMS (SCS-CN +Modclark)	Regional	3	1	event-based	1	2	1	1	1	conceptual	4	3	distributed (gridded)	5	3	not provid ed	3	1	overland flow	1	1	1	37.00	60.00
4	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	-	0	1	-	0	1	1	0.00	60.00
5	ModSpa	basin	4	1	event-based	1	2	30	5	1	conceptual physically based	4.5	3	distributed	5	3	1 h to 15 min	5	1	overland & channel flow	3	1	1	47.50	60.00
6	modified SCS + linear lag & route	basin	4	1	event-based	1	2	21	5	1	conceptual	4	3	distributed	5	3	1 h	5	1	overland flow	1	1	1	44.00	60.00
7	HEC-HMS	basin	4	1	event-based	1	2	8	3	1	conceptual	4	3	semi-distributed	4	3	1 h	5	1	overland & channel flow	3	1	1	41.00	60.00
8	TOPMODEL + Muskingum–Cunge–Todini	Basin	4	1	event-based	1	2	1	1	1	physically based	5	3	distributed	5	3	5 min	5	1	overland, channel & sub-surface flow	4	1	1	46.00	60.00
9	Nash IUH	basin	4	1	event-based	1	2	2 + 5	2.5	1	conceptual	3	3	lumped	1	3	hourly	5	1	overland flow	1	1	1	26.50	60.00
10	TOPKAPI	basin	4	1	continuous	5	2	6 month + 1 year	2.5	1	physically based	5	3	distributed	5	3	6-hour	4	1	overland, channel, inter flow, groundwater …	5	1	1	55.50	60.00
11	2D DW rainfall-runoff model	basin	4	1	1 event 36 day period (25 Aug to 30 Sept)	4	2	36 days/1 event	1	1	physically based	5	3	distributed	5	3	adaptiv e time step	5	1	Overland & channel flow, infiltration, saturated sub-surface flow…	5	1	1	53.00	60.00
12	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	-	0	1	-	0	1	1	0.00	60.00
13	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	-	0	1	-	0	1	1	0.00	60.00
14	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	-	0	1	-	0	1	1	0.00	60.00
15	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	-	0	1	-	0	1	1	0.00	60.00
16	SCS-LR	basin	4	1	event-based	1	2	34 events	5	1	conceptual	4	3	distributed	5	3	30 min	5	1	overland flow	1	1	1	44.00	60.00
17	GIS hydro processing	regional	2	1	not provided	3	2	1 simula tion	2	1	flow acc./dir.	2	3	distributed	5	3	NA	0	1	flow acc./dir.	1	1	1	32.00	60.00
18	GIS hydro processing	regional	2	1	not provided	3	2	ditto	2	1	flow acc./dir.	2	3	distributed	5	3	NA	0	1	flow acc./dir.	1	1	1	32.00	60.00

Hydrological model																		
Procedural model				Cost of code		Max. cost	model calibration/ validation/ uncertainty analysis						Cost of calibration/ uncertainty…		Max. cost	Total cost of Hydrologic model	Max. cost of Hydrologic model
Study case ID	code development						Nb. of parameters to calibrate			type of input and parameter specification							
	Des.	S	W	Sub-category weight	Total	Total	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total		
1	ready to wear	1	2	1	5.00	15.00	3	2	1	stochastic: Unct. on parameters	3	1	2	10.00	20.00	53.00	95.00
2	ready to wear	1	2	1	3.00	15.00	no calibration	0	1	deterministic	1	1	2	2.00	20.00	20.00	95.00
3	ready to wear	1	2	1	5.00	15.00	4	3	1	deterministic	1	1	2	8.00	20.00	50.00	95.00
4	-	0	2	1	0.00	15.00	-	0	1	-	0	1	2	0.00	20.00	0.00	95.00
5	tailor-made	5	2	1	14.50	15.00	4 to 6	3	1	deterministic	1	1	2	8.00	20.00	70.00	95.00
6	modify existing code	3	2	1	9.00	15.00	5	3	1	deterministic	1	1	2	8.00	20.00	61.00	95.00
7	ready to wear	1	2	1	5.00	15.00	5	3	1	stochastic: Unct. on parameters & input rainfall	4	1	2	14.00	20.00	60.00	95.00
8	ready to wear	1	2	1	6.00	15.00	6	4	1	stochastic: Unct. on parameters & input rainfall	5	1	2	18.00	20.00	70.00	95.00
9	ready to wear	1	2	1	3.00	15.00	3	2	1	stochastic: Unct. on parameters	3	1	2	10.00	20.00	39.50	95.00
10	modify existing code	3	2	1	11.00	15.00	around 27	5	1	deterministic	1	1	2	12.00	20.00	78.50	95.00
11	ready to wear	1	2	1	6.00	15.00	5	3	1	deterministic	1	1	2	10.00	20.00	69.00	95.00
12	-	0	2	1	0.00	10.00	-	0	1	-	0	1	2	0.00	20.00	0.00	90.00
13	-	0	2	1	0.00	10.00	-	0	1	-	0	1	2	0.00	20.00	0.00	90.00
14	-	0	2	1	0.00	10.00	-	0	1	-	0	1	2	0.00	20.00	0.00	90.00
15	-	0	2	1	0.00	10.00	-	0	1	-	0	1	2	0.00	20.00	0.00	90.00
16	available	1	2	1	2.00	10.00	5	4	1	deterministic	1	1	2	10.00	20.00	56.00	90.00
17	available	1	2	1	2.00	10.00	estimated (b & n, hydraulic scaling)	0	1	deterministic	1	1	2	2.00	20.00	36.00	90.00
18	available	1	2	1	2.00	10.00	2 (scale b & n hydraulic scaling)	2	1	deterministic	1	1	2	6.00	20.00	40.00	90.00

Hydraulic model																			
Type of hydraulic model																		Cost of hydraulic model type		Max. cost
Study case ID	Type	Spatial scale			Temporal scale			Nb. of events/ Duration			Flow equations			Spatial representation					
	Des.	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
1	HEC-RAS	downstream reach (5 km)	5	1	event-based	1	2	1	1	1	1D SV	5	3	1D	1	3	1	26.00	50.00
2	HEC-RAS	downstream reach (5 km)	5	1	event-based	1	2	1	1	1	1D SV	5	3	1D	1	3	1	26.00	50.00
3	HEC-RAS	regional (6 major streams)	3	1	event-based	1	2	1	1	1	1D SV	5	3	1D	1	3	1	24.00	50.00
4	Sub-Grid LISFLOOD-FP	regional (9500 km of river network)	3	1	Continuous	4.5	2	8 years	3	1	KW/DW	4	3	1D/2D	4	3	1	39.00	50.00
5	No info	one reach	5	1	event-based	1	2	-	5	1	DW	4	3	1D	1	3	1	27.00	50.00
6	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	1	0.00	50.00
7	HEC-RAS	downstream reach (6 km)	5	1	event-based	1	2	1	1	1	1D SV	5	3	1D	1	3	1	26.00	50.00
8	Sub-Grid LISFLOOD-FP	downstream floodplain (13 km)	5	1	event-based	1	2	1	1	1	KW/DW	4	3	1D/2D	4	3	1	32.00	50.00
9	HEC-RAS	19 km river reach	5	1	event-based	1	2	2	1	1	1D SV	5	3	1D	1	3	1	26.00	50.00
10	-	-		1	-	-	2	-	-	1	-	-	3	-	-	3	1	0.00	50.00
11	1D DW in channel	Main basin channels	5	1	36 days/1 event	3	2	1	1	1	DW	4	3	1D/2D	4	3	1	36.00	50.00
12	HEC-RAS	60 km reach	5	1	event-based	1	2	2	1	1	1D SV	5	3	1D	1	3	1	26.00	50.00
13	LISFLOOD-FP	60 km reach	5	1	event-based	1	2	2	1	1	DW	4	3	2D raster	3	3	1	29.00	50.00
14	TELEMAC-2D	60 km reach	5	1	event-based	1	2	2	1	1	SV	5	3	2D finite element	4	3	1	35.00	50.00
15	TELEMAC-2D	12 km reach	5	1	event-based	1	2	2	1	1	SV	5	3	2D finite element	4	3	1	35.00	50.00
16	-	-	0	1	-	0	2	-	0	1	-	0	3	-	0	3	1	0.00	50.00
17	GFA GIS-tool	regional	2	1	30 min -2 h per basin (5 basins)	4	2	1 scenario	3	1	empirical (based on hydraulic scaling)	1	3	2D	3	3	1	25.00	50.00
18	Geomorphic Flood Index (GFI) compared with 3 other geomorphic indices	regional	2	1	no information	3	2	1 scenario	3	1	empirical (based on hydraulic scaling)	1	3	2D	3	3	1	23.00	50.00

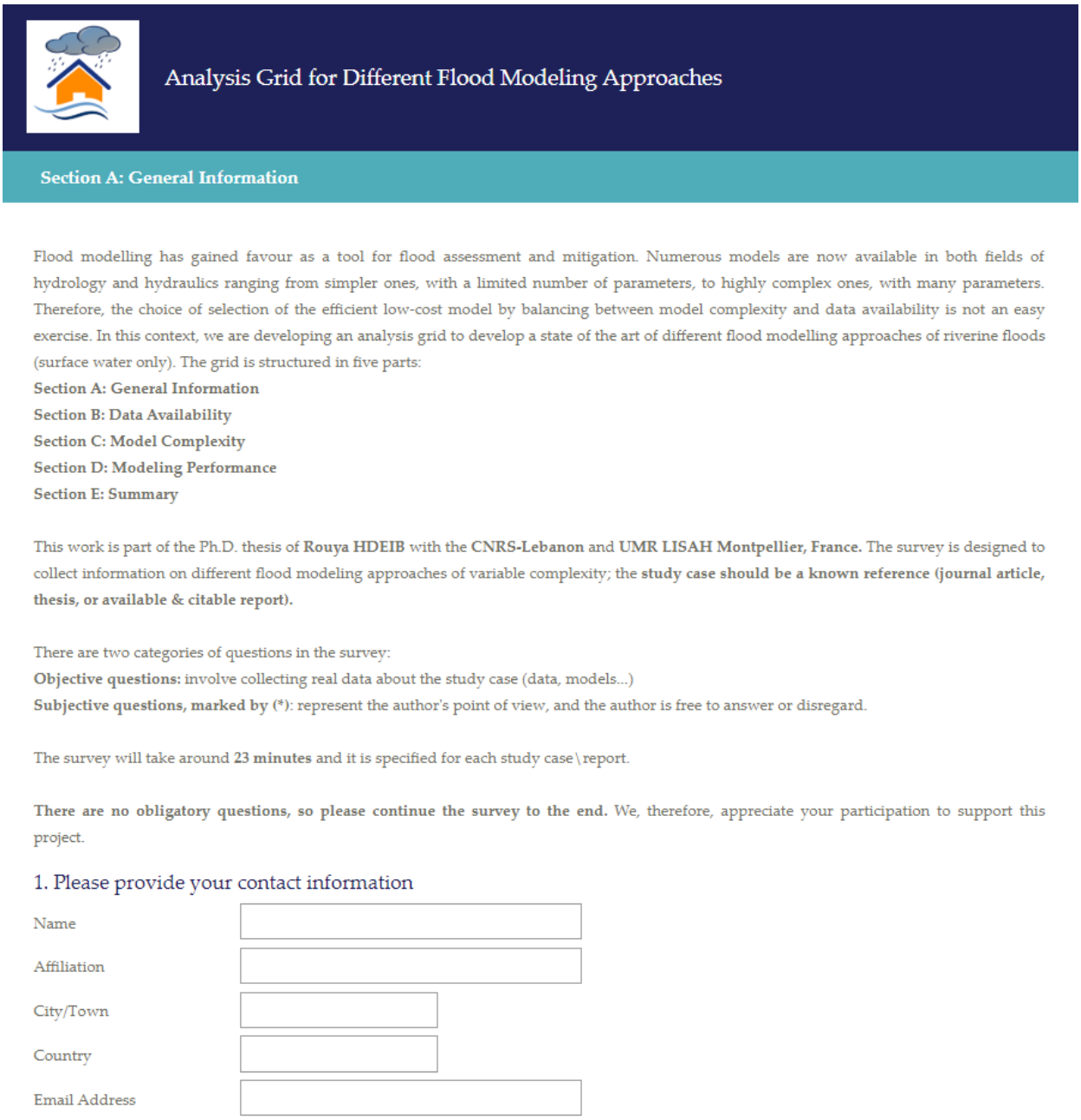
Hydraulic model						
Procedural model				Cost of code		Max. cost of code
Study case ID	code development					
	Des.	S	W	Sub-category weight	Total	Total
1	ready to wear	1	2	1	5.00	15.00
2	ready to wear	1	2	1	5.00	15.00
3	ready to wear	1	2	1	5.00	15.00
4	modify existing code	3	2	1	10.00	15.00
5	tailor-made	5	2	1	14.00	15.00
6	-	0	2	1	0.00	15.00
7	ready to wear	1	2	1	5.00	15.00
8	ready to wear	1	2	1	6.00	15.00
9	ready to wear	1	2	1	5.00	15.00
10	-	0	2	1	0.00	15.00
11	ready to wear	1	2	1	6.00	15.00
12	ready to wear	1	2	1	2.00	10.00
13	ready to wear	1	2	1	2.00	10.00
14	ready to wear	1	2	1	2.00	10.00
15	ready to wear	1	2	1	2.00	10.00
16	-	0	2	1	0.00	10.00
17	developed	5	2	1	10.00	10.00
18	computed in GIS	2	2	1	4.00	10.00

Hydraulic model											
model calibration/ validation/ uncertainty analysis							Cost of calibration/ validation/ uncertainty evaluation		Max. cost	Total cost of Hydraulic model	Max. cost of Hydraulic model
Study case ID	number of parameters to calibrate			type of input and parameter specification							
	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total		
1	1	1	1	stochastic input	3	1	2	8.00	20.00	39.00	85.00
2	1	1	1	deterministic	1	1	2	4.00	20.00	35.00	85.00
3	1	1	1	deterministic	1	1	2	4.00	20.00	33.00	85.00
4	3	2	1	deterministic	1	1	2	6.00	20.00	55.00	85.00
5	No info	0	1	deterministic	1	1	2	2.00	20.00	43.00	85.00
6	-	0	1	-	0	1	2	0.00	20.00	0.00	85.00
7	1	1	1	stochastic input	3	1	2	8.00	20.00	39.00	85.00
8	3 (6 boundary conditions)	3	1	stochastic parameter and input	5	1	2	16.00	20.00	54.00	85.00
9	2 parameters (channel and floodplain roughness), 1 downstream boundary condition, 1 upstream boundary condition	2	1	stochastic parameter and input	5	1	2	14.00	20.00	45.00	85.00
10	-	0	1	-	0	1	2	0.00	20.00	0.00	85.00
11	Same model parameters	0	1	deterministic	1	1	2	2.00	20.00	44.00	85.00
12	friction coefficient calibration	1	1	deterministic/ sensitivity analysis	2	1	2	6.00	20.00	34.00	80.00
13	friction coefficient calibration	1	1	deterministic/ sensitivity analysis	2	1	2	6.00	20.00	37.00	80.00
14	friction coefficient calibration	1	1	deterministic/ sensitivity analysis	2	1	2	6.00	20.00	43.00	80.00
15	friction coefficient calibration	1	1	deterministic/ sensitivity analysis	1	1	2	4.00	20.00	41.00	80.00
16	-	0	1	-	0	1	2	0.00	20.00	0.00	80.00
17	1 (τ stream threshold)	1	1	deterministic	1	1	2	4.00	20.00	39.00	80.00
18	1 (τ stream threshold)	1	1	deterministic	1	1	2	4.00	20.00	31.00	80.00

Performance of modelling		

Type of output			Criteria function			Peak flow & volume error			hydrograph error			water level error			flood extent error			Performance of models		Max. Perf.
Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Des.	S	W	Sub-category weight	Total	Total
flood inundation map	5	3	multi variable/nash optimization	3	2	Peak error, 20%	2	1	Nash, 0.6	2	1	RMSE, 0.26 m	4	1	not available	0	1	1	29.00	45.00
water levels	4	3	single variable/ single criteria	1	2	peak flow error 50%	1	1	-	0	1	-	0	1	-	0	1	1	15.00	45.00
flood inundation map	5	3	multi variable/ multicriteria	3	2	not calculated, around 30%	2	1	avrg. MAE, 66%; R, 0.78	2	1	not calculated	0	1	with Landsat ~ 0.45 match	2	1	1	27.00	45.00
flood inundation map	5	3	multi variable/ multicriteria	5	2	not calculated	2	1	Nash, 0.91	4	1	RMSE, 1.26	2	1	between 0.4 and 0.7	3	1	1	36.00	45.00
flow hydrograph @ outlet	2	3	single variable/ multicriteria	3	2	peak flow error 30%	2	1	Nash, 0.3 to 0.8	3	1	-	0	1	-	0	1	1	17.00	45.00
flow hydrograph @ outlet	2	3	multi variable/ multicriteria	5	2	peak flow error 15 %	3	1	Nash, 0.69 to 0.75	4	1	-	0	1	-	0	1	1	23.00	45.00
water levels	4	3	multi variable/ multicriteria	4	2	peak flow error 0.2%	5	1	Nash, 0.78	4	1	@ 1 section, 0.4%	2	1	-	0	1	1	31.00	45.00
flood inundation map	5	3	likelihood measure of a simulation: the degree of belief of a trapezoidal fuzzy membership function	4	2	peak flow uncertainty range 50%	1	1	peak flow & phase uncertainty: 20 to 50% and 0.5 to 2.5 hrs respectively	2	1	between 0.5 and 1.8 m error	3	1	not evaluated, comparison on previous study (~ 60% match)	0	1	1	29.00	45.00
flood inundation map	5	3	multi variable/ multicriteria	4	2	not calculated, around 13%	3	1	Nash, 0.95	4.5	1	match score of 0.84	3	1	92% of surveyed flood marks in confidence bounds of SAR-derived flood	3.5	1	1	37.00	45.00
runoff at each cell	4	3	parameter adjustment by trial and error	2	2	calibration: -10.5% validation: 4.4%	3	1	R 0.844	3	1	not evaluated	0	1	not evaluated	0	1	1	22.00	45.00
flood inundation map	5	3	multi variable/ multicriteria	3	2	-		1	NSE between -1.32 and 0.96, median at 0.86	4	1	not evaluated	0	1	measure of fit: 0.87 (pre-flood & flood peak), 0.3 (flood recession period	4	1	1	28.50	45.00
flood inundation map	5	3	single variable/ multicriteria	2	2	not evaluated	3	1	not evaluated	3	1	not evaluated	0	1	measure of fit F 37.79 - 64.83 (~51.59)	2.5	1	1	27.50	45.00
flood inundation map	5	3	single variable/ multicriteria	2	2	not evaluated	3	1	not evaluated	3	1	not evaluated	0	1	measure of fit F 37.06 - 63.81 (~46.72)	2	1	1	27.00	45.00
flood inundation map	5	3	single variable/ multicriteria	2	2	not evaluated	3	1	not evaluated	3	1	not evaluated	0	1	measure of fit F 37.13 - 65.21 (~50.4)	2.5	1	1	27.50	45.00
flood inundation map	5	3	single variable/single criteria	1	2	visual comparison of hydrographs (around 4% error)	4	1	not evaluated, but provided two hydrographs comparison	4	1	not evaluated	0	1	comparison between standard and LIDAR DEM's	1	1	1	26.00	45.00
Flow hydrograph @ outlet	2	3	multi variable/ multicriteria	5	2	peak flow error 15 %	3	1	Nash, 0.71 to 0.92	4	1	-	0	1	-	0	1	1	23.00	45.00
Flood prone area map 30m	4	3	single variable/single criteria	1	2	-	0	1	-	0	1	-	0	1	Obj. function=RFN+RFP (~41.64)	1	1	1	15.00	45.00
Flood prone area map 90m	4	3	single variable/multi criteria	2	2	-	0	1	-	0	1	-	0	1	GFI index: RFP (between 0.1 and 0.4), RTP (between 0.7 and 0.95)	2	1	1	18.00	45.00

Figure S1: Some screen shots for the designed online survey, particularly for the first section (Section A).



Analysis Grid for Different Flood Modeling Approaches

Section A: General Information

Flood modelling has gained favour as a tool for flood assessment and mitigation. Numerous models are now available in both fields of hydrology and hydraulics ranging from simpler ones, with a limited number of parameters, to highly complex ones, with many parameters. Therefore, the choice of selection of the efficient low-cost model by balancing between model complexity and data availability is not an easy exercise. In this context, we are developing an analysis grid to develop a state of the art of different flood modelling approaches of riverine floods (surface water only). The grid is structured in five parts:

Section A: General Information
Section B: Data Availability
Section C: Model Complexity
Section D: Modeling Performance
Section E: Summary

This work is part of the Ph.D. thesis of **Rouya HDEIB** with the **CNRS-Lebanon** and **UMR LISAH Montpellier, France.** The survey is designed to collect information on different flood modeling approaches of variable complexity; the **study case should be a known reference (journal article, thesis, or available & citable report).**

There are two categories of questions in the survey:
Objective questions: involve collecting real data about the study case (data, models...)
Subjective questions, marked by (*): represent the author's point of view, and the author is free to answer or disregard.

The survey will take around **23 minutes** and it is specified for each study case\report.

There are no obligatory questions, so please continue the survey to the end. We, therefore, appreciate your participation to support this project.

1. Please provide your contact information

Name

Affiliation

City/Town

Country

Email Address

2. Please provide information on the study case.

Title	
Year	
Study site	
Country & City	
Reference/ citation/ doi	

3. Objective/output required from the modeling approach.
Please select all that applies.

note: some objectives may be nested (ex: obtaining a flow hydrograph involves obtaining the flood peak flow)

- [ ] flood peak discharge
- [ ] flood water levels
- [ ] flood flow hydrograph at one location/outlet
- [ ] flood inundation map
- [ ] flood flow hydrograph at different locations
- [ ] Other (please specify)

4. Level of data acquisition

- ( ) ungauged
- ( ) research basin
- ( ) poorly-guaged
- ( ) new acquisitions
- ( ) classical
- ( ) Other (please specify)

5. Scale of the study site

- ( ) parcel/field
- ( ) continental
- ( ) basin
- ( ) global
- ( ) regional
- ( ) Other (please specify)

6. Study site area range

- ◯ [0; 100] Sqkm
- ◯ [101; 1000] Sqkm
- ◯ [1001; 10,000] Sqkm
- ◯ [10,001; 100,000] Sqkm
- ◯ more than 100,000 Sqkm

Please specify the study site area

7. * Why did you choose this study site?

8. Please select to which category does your flood modelling approach belong

- ◯ Category 1: Empirical, statistical, regionalization, etc...
- ◯ Category 2: Single application of a hydraulic model 1D, 2D, or 3D
- ◯ Category 3: Simplified hydraulic conceptual model
- ◯ Category 4: Single application of a hydrological model
- ◯ Category 5: Coupled hydrological-hydraulic model
- ◯ Category 6: Geomorphic approach
- ◯ Other (please specify)

Next