Appendix 2
In this appendix, we explain the main steps of the Qualitative Comparative Analysis.

Table A2.1 Raw data matrix

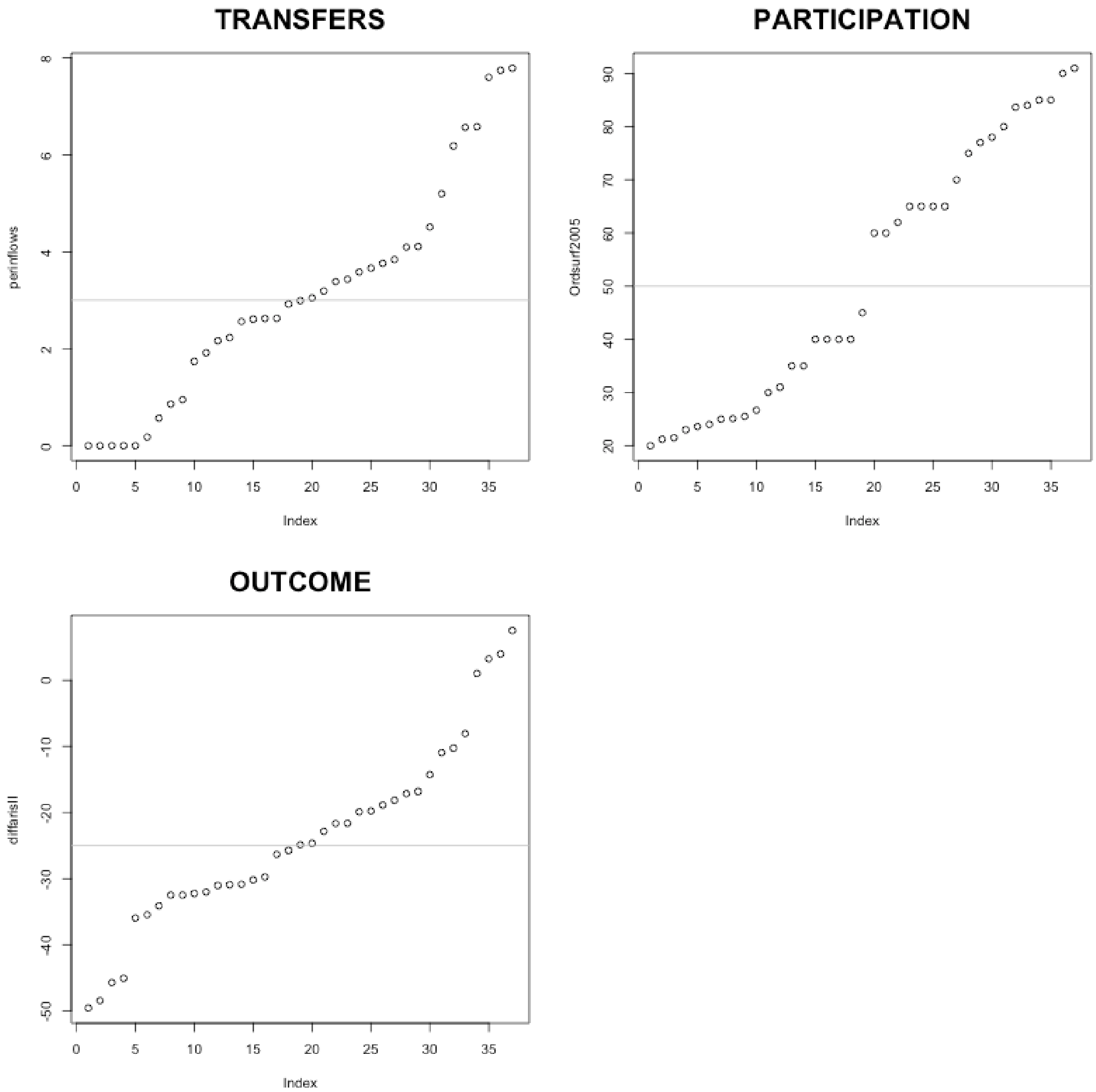
SYSTEM	CLUSTER	TRANSFERS	PARTICIPATION	MONITORING	DIFF. DROUGHT PERFORMANCE (i.e., DROUGTH ADAPTATION)
ALBERO BAJO	1	2,6	60	0	7,5
ALCALA DE GURREA	1	0,0	62	0	3,3
ALMUDEVAR	1	0,9	85	0	-26,3
BARBUES	1	0,2	91	0	-31,0
EL TEMPLE	1	4,1	65	0	-45,1
GRAÑEN FLUMEN	1	1,9	35	0	-19,9
JOAQUIN COSTA	1	0,0	23	1	-49,6
LALUEZA	1	7,6	25	0	-32,0
LANAJA	1	3,8	60	1	-18,9
PIRACES	1	2,6	70	0	-21,6
SANGARREN	1	0,6	27	0	-19,8
TARDIENTA	1	3,2	20	1	-18,1
TORRALBA	1	0,9	65	0	-32,2
VALFONDA	1	3,4	45	0	-32,5
VICIEN	1	0,0	90	0	-45,7
ALCONADRE	0	3,7	84	0	-10,9
CANDASNOS	0	0,0	77	0	-29,7
CARTUJA-SAN JUAN	0	2,2	31	0	-30,8
LA SABINA	0	6,6	25	0	-21,6
LAS ALMACIDAS	0	2,6	80	1	-25,7
LASESA	0	7,7	22	1	-24,9
SAN MIGUEL	0	3,0	78	0	-34,1
SAN PEDRO	0	7,8	40	1	-17,2
SANTA CRUZ	0	3,6	75	1	-32,5
VAL DE ALFERCHE	0	2,9	40	0	-10,3
ALMUNIENTE	1	0,0	30	1	-36,0
CALLEN	1	5,2	65	0	1,0
LLANOS DE CAMARERA	1	2,2	65	0	-22,8
N1 CANAL DEL CINCA	1	1,7	24	0	4,0
SAN JUAN	1	3,8	40	0	-14,3
TORRES DE BARBUES	1	3,0	84	0	-48,5
COLLARADA 2	0	4,5	85	1	-30,9
ORILLENA	0	4,1	21	0	-35,5
SECTOR VII FLUMEN	0	2,6	26	0	-30,2
SECTOR VIII MONEGROS	0	3,4	24	0	-24,7
SECTOR X FLUMEN	0	6,6	40	1	-16,8
SODETO-ALBERUELA	0	6,2	35	0	-8,1

In QCA parlance, Table A2.1 represents the “raw data matrix”, encompassing the available empirical evidence that will be used for analysis. The lines of a raw data matrix represent the “cases”, whereas the column represent the “measures” – the empirical evidence, in whatever form it may come. In light of the binary nature of some of the measures (“Cluster” and “Monitoring”) involved in the analysis, we opt for a crisp-set QCA (csQCA).

The first step in a QCA is called “calibration” and consists in translating measures into membership scores (whether the cases at stake belong or do not belong to those “sets” representing the conditions for analysis). Since the analysis relies on crisp sets (and not on fuzzy sets or categorial variables), membership scores will be either 1 (full membership: case belongs to the set) or 0 (full membership in the negation of the set: case does not belong to the set).

How membership scores are obtained from the four variables above depends on the nature of the variable at hand. The variables CLUSTER and MONITORING are binary, and thus inherently represent memberships in particular sets. The variables TRANSFERS, PARTICIPATION and DROUGHT ADAPTATION are instead numeric and represent quantities. Converting them into membership scores requires setting thresholds that reflect qualitative changes between cases, in line with the definition of each specific set. With this in mind, thresholds for TRANSFERS, PARTICIPATION andDROUGHT ADAPTATION were set at 3%, 50%, and -25%, respectively.

Figure A2.1 – Calibration of non-binary measures



Note that these thresholds are rather close to the median value for each measures, thus ensuring sufficient variation in the resulting sets, yet they were chosen for being substantively meaningful, and not for their relation to the median value. In the case of TRANSFERS, 3% may look small but it is considerable considering that the transfer institution was designed as a measure to tweak the quota allocations at the margins. In the case of PARTICIPATION, 50% of participation (as per hectares represented) made sense, given that decisions in the WUA assemblies are made based on the number of hectares represented. DROUGHT ADAPTATION is used here as our outcome ("OUTCOME" from now on). In the present context, a drop in irrigation performance smaller than 25% can be considered a success (i.e., successful drought adaptation), given that (1) the drought meant a reduction in available water by 60%, and (2) farmers consider that up to 30% of water stress is not severely detrimental for production (although this varies with agronomic conditions). Irrigation systems with a differential in irrigation performance higher than -25% are therefore members of OUTCOME (membership score = 1), while systems with differentials below -25% are not (membership score = 0).

Table A2.2 Membership scores

	CLUSTER	TRANSFERS	PARTICIPATION	MONITORING	OUTCOME
ALBERO BAJO	1	0	1	0	1
ALCALA DE GURREA	1	0	1	0	1
ALMUDEVAR	1	0	1	0	0
BARBUES	1	0	1	0	0
EL TEMPLE	1	1	1	0	0
GRAÑEN FLUMEN	1	0	0	0	1
JOAQUIN COSTA	1	0	0	1	0
LALUEZA	1	1	0	0	0
LANAJA	1	1	1	1	1
PIRACES	1	0	1	0	1
SANGARREN	1	0	0	0	1
TARDIENTA	1	1	0	1	1
TORRALBA	1	0	1	0	0
VALFONDA	1	1	0	0	0
VICIEN	1	0	1	0	0
ALCONADRE	0	1	1	0	1
CANDASNOS	0	0	1	0	0
CARTUJA-SAN JUAN	0	0	0	0	0
LA SABINA	0	1	0	0	1
LAS ALMACIDAS	0	0	1	1	0
LASESA	0	1	0	1	1
SAN MIGUEL	0	1	1	0	0
SAN PEDRO	0	1	0	1	1
SANTA CRUZ	0	1	1	1	0
VAL DE ALFERCHE	0	0	0	0	1
ALMUNIENTE	1	0	0	1	0
CALLEN	1	1	1	0	1
LLANOS CAMARERA	1	0	1	0	1
N1 CANAL DEL CINCA	1	0	0	0	1
SAN JUAN	1	1	0	0	1
TORRES DE BARBUES	1	1	1	0	0
COLLARADA 2	0	1	1	1	0
ORILLENA	0	1	0	0	0
SECTOR VII FLUMEN	0	0	0	0	0
SECTOR VIII MONEGROS	0	1	0	0	1
SECTOR X FLUMEN	0	1	0	1	1
SODETO-ALBERUELA	0	1	0	0	1

The next step in a standard analysis consists in testing whether any of the conditions at stake represent an *individually necessary* condition for the presence of the outcome. Ideally, a condition is necessary (and fully consistently so) if the OUTCOME is never observed without it. Full consistency is not required, though. Conventionally, conditions are deemed necessary if their consistency score for necessity is above 0.9. In a crisp-set setting, this is the same as saying that less than ten percent of the cases are allowed to contradict the necessity claim. It is also important that a condition is not trivially necessary, i.e., that it corresponds to a set so large as to include almost all cases – making counterfactual analysis virtually impossible.

Table A2.3 Consistency and coverage scores for necessity

	Consistency	Coverage
CLUSTER	0.579	0.524
PARTICIPATION	0.368	0.389
TRANSFERS	0.579	0.611
STR_MONITORING	0.263	0.5

Consistency and coverage scores for necessity are presented in Table A2.3. As one can see, no condition is individually necessary. If any of them would be necessary, a very high coverage score (well above 0.75) would hint at a trivially necessary condition. This is however not the case.

The analysis of necessity is then followed by the analysis of *sufficiency*, which consists of the analysis of the truth table, followed by logical minimization. Paths with a consistency score equal or higher than 0.75 are considered sufficient for the outcome. Paths have been sorted based on the inclusion score.

Table A2.4 Truth table for analysis of sufficiency for successful drought adaptation (OUTCOME=1)

TRANSFERS	PARTICIPATION	MONITORING	CLUSTER	OUT	n	incl	PRI
0	0	0	1	1	3	1.000	1.000
1	0	1	0	1	3	1.000	1.000
1	0	1	1	1	1	1.000	1.000
1	1	0	0	1	1	1.000	1.000
1	1	1	1	1	1	1.000	1.000
1	0	0	0	1	4	0.750	1.000
0	1	0	1	0	8	0.500	0.500
0	0	0	0	0	3	0.333	0.333
1	0	0	1	0	3	0.333	0.333
1	1	0	1	0	3	0.333	0.333
0	0	1	1	0	2	0.000	0.000
0	1	0	0	0	2	0.000	0.000
0	1	1	0	0	1	0.000	0.000
1	1	1	0	0	2	0.000	0.000
0	0	1	0	?	0	-	-
0	1	1	0	?	0	-	-

Note 1: The "OUT" column indicates whether the path represents a sufficient condition for the outcome set. The "n" column indicates how many cases populate the respective path. The "incl" column indicates the "inclusion score", that is, the consistency score for sufficiency for the path. Paths with a consistency score equal or higher than 0.75 are considered sufficient for the outcome. Paths have been sorted based on the inclusion score. Note 2: In light grey the paths included in the minimization.

A QCA standard analysis encompasses three types of solutions: complex, intermediate, and parsimonious. The difference between them lies in the use of logical minimization, and in the introduction of assumptions concerning logical remainders. Specifically, complex solutions involve no logical minimization and is equal to the union of all sufficient paths from the truth table; intermediate solutions involve logical minimization, but only among observed, consistent paths. Parsimonious solutions involve logical minimizations and include logical remainders, implying assumptions concerning those paths that were not observed. All three types of solutions have their own merits and drawbacks. As a standard of good practice, all three solutions are reported. This is a sign of transparency and allows for an informed choice on which solution to rely on when interpreting the results. The complex solution is reported below in Table A2.5. It has an overall consistency score of 0.923 and a coverage score of 0.632. The intermediate solution is reported in the article's main text and will not be duplicated here. The parsimonious solution is equivalent to the intermediate solution, since none of the logical remainder is capable of minimizing the solution formula any further.

Table A2.5 Complex solution to successful drought adaptation (OUTCOME=1)

	Complex solution CONS, COV: 0.923, 0.632
Cluster-independent	--
Asian model (CLUSTER)	transfers*participation*monitoring TRANSFERS*participation*MONITORING TRANSFERS*PARTICIPATION*MONITORING
American model (cluster)	TRANSFERS*participation*MONITORING TRANSFERS*PARTICIPATION*monitoring TRANSFERS*participation*monitoring

QCA is characterized by asymmetrical causation. This implies that membership in the negation of the outcome requires its own analysis and cannot be inferred from the solution formula explaining membership in the outcome set. In the context of the present analysis, this implies that explaining unsuccessful drought adaptation requires its own analyses of necessity and sufficiency. Below, the reader can find the consistency and coverage score for necessity for all conditions at stake, the truth table for the negation of the outcome, and the paths for both the complex and parsimonious solutions (the intermediate is used in the main text).

Table A2.6 Analysis of necessity for unsuccessful drought adaptation (OUTCOME=0)

	Consistency	Coverage
CLUSTER	0.556	0.476
PARTICIPATION	0.611	0.611
TRANSFERS	0.389	0.389
STR_MONITORING	0.278	0.5

No condition is individually necessary for the outcome.

Table A2.7 Truth table for analysis of sufficiency for unsuccessful drought adaptation (OUTCOME=0)

TRANSFERS	PARTICIPATION	MONITORING	CLUSTER	OUT	n	incl	PRI
0	0	1	1	1	2	1.000	1.000
0	1	0	0	1	2	1.000	1.000
0	1	1	0	1	1	1.000	1.000
1	1	1	0	1	2	1.000	1.000
0	0	0	0	0	3	0.667	0.667
1	0	0	1	0	3	0.667	0.667
1	1	0	1	0	3	0.500	0.500
0	1	0	1	0	8	0.250	0.250
1	0	0	0	0	4	0.000	0.000
0	0	0	1	0	3	0.000	0.000
1	0	1	0	0	3	0.000	0.000
1	0	1	1	0	1	0.000	0.000
1	1	0	0	0	1	0.000	0.000
1	1	1	1	0	1	0.000	0.000
0	0	1	0	0	0	-	-
0	1	1	1	0	0	-	-

Table A2.8 Complex and parsimonious solutions to unsuccessful drought adaptation (OUTCOME=0)

	Complex solution CONS, COV: 0.1, 0.389	**Parsimonious solution** CONS, COV: 0.1, 0.389
Cluster-independent	--	transfers*MONITORING
Asian model (CLUSTER)	transfers*participation*MONITORING	--
American model (cluster)	transfers*PARTICIPATION*monitoring transfers*PARTICIPATION*MONITORING TRANSFERS*PARTICIPATION*MONITORING	transfers*PARTICIPATION PARTICIPATION*MONITORING

Finally, some considerations are worthwhile concerning the role of CLUSTER in the analysis, introducing an additional differentiation in what would have otherwise been an analysis of OUTCOME as a product of TRANSFERS, PARTICIPATION, and MONITORING. The set-theoretic nature of QCA ensures that, to the extent CLUSTER does not contribute to explaining OUTCOME, it will not appear in the results. It's because of this that some of the paths presented above are cluster-independent. One can think of them as the results of two separate analyses, one addressing CLUSTER cases, the other addressing ~CLUSTER cases. Each path that is common to both analyses effectively makes the distinction of cases along CLUSTER irrelevant.

Formally, if the truth table would show that

CLUSTER * TRANSFERS * MONITORING => OUTCOME

while also showing that

~CLUSTER * TRANSFERS * MONITORING => OUTCOME

Logical minimization would then infer that

TRANSFERS * MONITORING => OUTCOME

By the same token, all paths that are not cluster-independent would not appear if CLUSTER was not considered. One can see that by replicating the analysis without CLUSTER. The analysis of necessity would not change, since it focuses on individual conditions. The analysis of sufficiency would instead provide the following truth tables (one for OUTCOME, the other one for ~OUTCOME).

Table A2.9 Truth table for analysis of sufficiency for successful drought adaptation without CLUSTER

TRANSFERS	PARTICIPATION	MONITORING	OUT	n	incl	PRI
1	0	1	1	4	1.000	1.000
0	0	0	0	6	0.667	0.667
1	0	0	0	7	0.571	0.571
1	1	0	0	4	0.500	0.500
0	1	0	0	10	0.400	0.400
1	1	1	0	3	0.333	0.333
0	0	1	0	2	0.000	0.000
0	1	1	0	1	0.000	0.000

Table A2.10 Truth table for analysis of sufficiency for unsuccessful drought adaptation without CLUSTER

TRANSFERS	PARTICIPATION	MONITORING	OUT	n	incl	PRI
0	0	1	1	2	1.000	1.000
0	1	1	1	1	1.000	1.000
1	1	1	0	3	0.667	0.667
0	1	0	0	10	0.600	0.600
1	1	0	0	4	0.500	0.500
1	0	0	0	7	0.429	0.429
0	0	0	0	6	0.333	0.333
1	0	1	0	4	0.000	0.000

Solution formulas would respectively be:

M1: TRANSFERS*participation*MONITORING => OUTCOME

and

M1: transfers*MONITORING => ~OUTCOME

Note how for OUTCOME the absence of logical remainders and the presence of only one path effectively prevent logical minimization. Complex, intermediate and parsimonious solutions are therefore identical. For ~OUTCOME, instead, two sufficient paths are available, and they allow for logical minimization, so that the complex and intermediate solution do differ.

The interesting observation is that both solution formulas above were also part of the solution formulas in the main analysis: they were not lost by adding an additional variable (CLUSTER). More specifically, the solution formula for OUTCOME corresponds to the cluster-independent path identified in the corresponding intermediate solution from the main analysis. The solution formula for ~OUTCOME appears in the parsimonious solution from the main analysis. Yet, both solutions cover only a tiny fraction of OUTCOME and ~OUTCOME: four out of 19 and three out of 18 cases, respectively. This corresponds to coverage scores of 0.210 and 0.166. Including CLUSTER increases coverage scores to 0.632 and 0.389, respectively. The greater nuance achieved by including CLUSTER, therefore, allows us to explain a much larger proportion of the phenomenon of interest.