above the 23 °C. The months with the highest temperature are April (23.03 ± 0.39 °C), March (22.99 ± 0.42 °C) and May (22.97 ± 0.41 °C), while the months with the lowest temperature are December (22.50 ± 0.46 °C), January (22.56 ± 0.46 °C) and November (22.55 ± 0.40 °C).

The interannual variations in temperature show two different behaviors between the period 1970-1989 and 1990-2015, in which there appears a tendency of increase of approximately 0.5 °C with significant fluctuations. Throughout the series there were several peaks of increase in temperature, but they stand out those occurred in the year 1998 and 2003 being the highest recorded. In 1989, a peak of reduction in temperature of about 1.5 °C was observed in comparison with the normal values, and before this year the fluctuations oscillated between 22 and 23 °C; after 1989 an increasing temperature trend is marked (Figure 8).

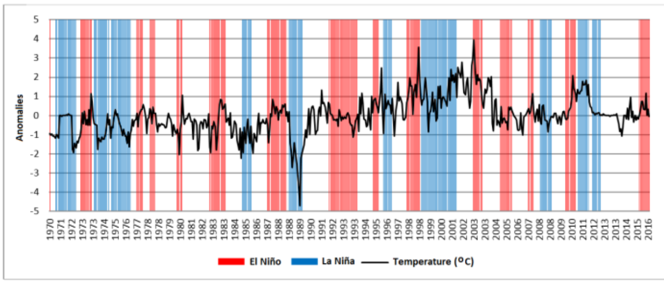

Figure 8. Interannual variability of precipitation and flow of the Rio de Oro in the middle-upper part of the basin.

According to the ONI, the direct influence of the macroclimatic events on temperature fluctuations over the period could be reveal. For this variable, a direct relationship between the positive (negative) TSM anomalies, the occurrence of El Niño (La Niña) events, and the positive (negative) temperature anomalies was find. The most marked negative anomaly occurred in 1989, when the La Niña event occurred.

Current water management system

Three planning instruments formulated by the CDMB were analyzed in the study region (28,29,30), and deficiencies and difficulties for their implementation in terms of climatic variability were identified. After the analysis it can be said that the CDMB's environmental management system is the result of a compendium of norms and adaptations of national instruments, and has been built through individual efforts towards the achievement of goals, without a proper representation to the regional reality, i.e., the activities in the planning processes respond more to the natural, water and geomorphological dimensions of the region, and not to the natural climatic variability, which should be the fundamental tool to apply, tending to the construction of processes, where the main goal is to preserve and make an integral management of the water resource.

Therefore, in the case of the CDMB and in the framework of the water management processes, both the PGAR, POMCA and PAT, which are existing instruments recognized by the Institution, define environmental actions related to administrative processes without involving the climatic variability. Thus, we have:

Regional Environmental Management Plan (PGAR)

The document was adopt in July 2014 and has a projection from 2015 to 2031. The work focused on the Alto Lebrija Basin, which includes the Río de Oro Sub-basin (Board of Directors Agreement No. 1113 of February 19, 2008). Thus, the numeral four point two (4.2) ***Strategic Lines: Integrated management of water resources,*** define within the pragmatic context a component of six programs: Offer water resources in the region (OWRR), demand of water resources in the region (DWRR), strengthening governance for water resource management (SGWR), quality of water resources in the region (QWRR), institutional strengthening for water resource management (ISWR), and integrated management of risks associated with supply and availability of the water (IMRW).

The PGAR assessment was done since the results of the numerical score obtained with *IESG* $_{N,}$ and presented in Table 4.

Table 4. Assessment of the criteria for the PGAR applying the methodology developed.

Strategic Line	Program	IM	OB	IN	GO	RI	CO	S T	C V	*IESG*	*IESG* $_N$
Integral Management Water Resources	ORHR	+	0	3	0	0	5	1	0	0.99	**0.00**
	DRHR	+	2	3	0	0	5	1	0	1.15	**100.00**
	FGRH	+	0	3	0	0	5	1	0	0.99	**0.00**
	CRHR	+	0	3	0	0	5	1	0	0.99	**0.00**
	FIRH	+	2	3	0	0	5	1	0	1.15	**100.00**
	GRDA	+	0	3	0	0	5	1	0	0.99	**0.00**

IM: Impact, OB: Objective, IN: Indicator, GO: Target, RI: Risk, CO: Coverage, ST: Strategy, CV: Climate variability. Source. *Authors Elaboration.*

The results in Table 4 show that the *demand of water resources in the region* and *institutional strengthening for the management of water resources,* are programs that in a critical way (33.33%) require changes in the short term, and include climate variability as an essential component within them. The remaining four programs: *Offer of water resources in the region, Strengthening governance for the management of water resources, quality of water resources in the region, and comprehensive management of the risks associated with supply and water availability,* represent 66.67%; in this case the inclusion of the climatic variability is little relevant, being in the direction of the CDMB its respective incorporation.

Plan of Management and Environmental Management Sub-basin of Rio de Oro (POMCA)

The structure of the plan is defined considering as planning instruments at a higher level of importance, the National Development Plan 2002-2006 "Towards a Community State" and the PGAR 2004-2015 "A platform for a sustainable environmental reality", and this one (1) based on two objectives:

a) Recovery and conservation of the natural and regional base that contains two strategic lines: Integral water resource management and conservation or sustainable use of soil and biodiversity.
b) Impetus to sustainable Regional development.

The management methodology used responds to what was describe in Decree 1729 of 2009. The formulation of the general objective was make very macro, and it´s lost in the real context of what would be the achievement of programs and projects of the strategic line of the resource water. It was evidence a well coordinate proposal when it was done a documentary review, however when analyzing in detail the coherence between objectives, goals, activities, indicators and schedules; A guiding thread was not distinguished, for example the objectives do not lead to the achievement of the goal, and that in turn this can be measured, controlled and evaluated by an indicator, in the three periods of execution (long term, medium term and short term).

A POMCA documentary review of five related to the strategic line ***Integral management of water resources*** projects was made, thus have: protection, restoration, conservation and watershed management suppliers of water and production systems (PCSP), assessment, management, regulation and distribution of water resources (EORH), technical and economic support to the municipalities of the sub-basin for the management, treatment and final disposal of domestic wastewater (ATAR), control of dumping and monitoring of the quality of the sub-basin (CVCS) flows, use and efficient water saving (UAEA).

The results of $IESG_N$ applied to projects are shown in Table 5. It was found that the proposed *use and efficient saving water,* proved to be the most critical (20% of total project) and therefore should be given greater attention (short term) in processes related to climate variability. In the medium term , the *Control of Dumping and quality monitoring of current sub – basin* project and in the long term the *Protection, recovery, conservation and management of supplying watersheds of aqueducts and production systems* project , involving in its water management system everything related to climatic variability, the above in order to guarantee the documentary coherence marked from the PGAR. While in the *assessment, management, regulation and distribution of water resources* project, the incorporation of climate variability it´s irrelevant.

Table 5. Evaluation of the criteria for the POMCA applying the methodology developed.

Programs	Projects	IM	OB	AC	IN	GO	RI	CO	C V	*IESG*	$IESG_N$
Integral Management Water Resource	PCSP	+	0	0	5	2	0	3	0	0.86	**39.02**
	EORH	+	0	0	1	2	0	3	0	0.54	**0.00**
	TIE	+	0	0	3	2	0	3	0	0.70	**19.51**
	CVCS	+	0	0	5	2	2	1	0	0.96	**51.22**
	UAEA	+	2	0	3	2	2	5	0	1.36	**100.00**

IM: Impact, OB: Objective, AC: Activity, IN: Indicator, GO: Target, RI: Risk, CO: Coverage, VC: Climate Variability. Source. *Authors* Elaboration

Table 6. Evaluation of the criteria for the PAT applying the methodology developed.

Program	Projects	IM	OB	AC	IN	GO	RI	CO	C V	*IESG*	*IESG* $_N$
Integral Management Water Resource	F EAM	+	0	0	3	2	0	5	0	0.90	**100.00**
	C MAJ	+	0	0	3	2	0	1	0	0.50	**0.00**

IM: Impact OB: Target, AC: Activity, IN: Indicator, GO: Meta, RI: Risk, CO: Coverage CV: Climate Variability. Source. Authors' Elaboration.

<u>*Triennial Action Plan (PAT)*</u>

Regarding the PAT there is no strategic line, but the ***Integrated Water Resources Management*** Program, has two projects: formulation of strategies for environmental planning (FEAM), and watershed conservation and management of protected areas for the supply of environmental goods and services in the area of jurisdiction (CMAJ).

In Table 6, it can be seen that the *formulation of strategies for environmental planning* project accounting the 50.00% of the total, highlights the need to act immediately (short - term) in terms of climate variability resulting irrelevant, the action on *watershed conservation and management of protected areas for the supply of goods and environmental services in the area of jurisdiction* project. It is to clarify that the priority given by the *IESG* $_N$ it´s only positional and does not constitute an obligation to implement the projects.

In the formulation of the three instruments itself demonstrates the need to relate GO, AC and IN, from a clearly defined in space and time perspective. For its part, the OB are formulated in a global context, apart from the particular and inherent in the sub - basin under study. The ST actions and the evaluation of programs and/or projects, lack clarity and do not allow applying improvement actions related to the environmental dynamics owner of the basin.

Proposed water management system

As part of a proposal water management system based on climate variability, a conceptual making decision model was built (Figure 9), that has like inputs (inflows), the basis of weather data (national and international), as processes mainstreaming of climate variability on all instruments of the water planning and as outputs, programs and or projects based on the seasonal scale in the four climatic periods that dominate in Colombia (DEF, MAM, JJA and SON).

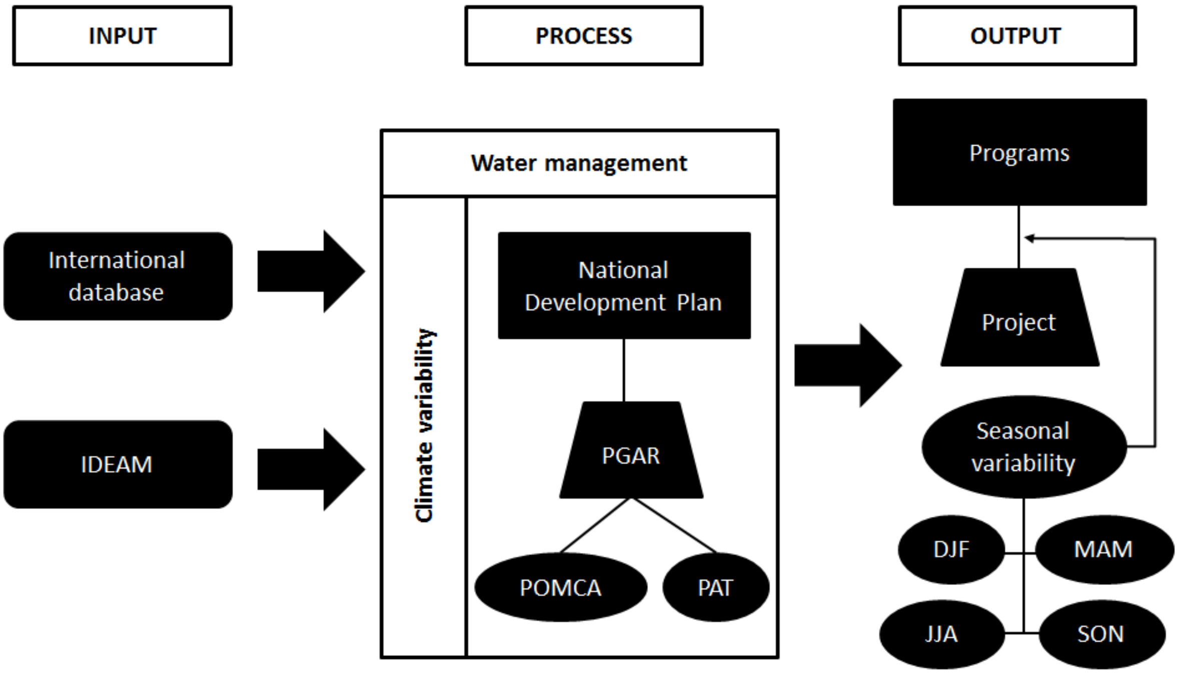

Figure 9. Conceptual model for water management proposed by CMDB.

Table 7. Correlation between variables in each of the climatic periods.

Variables	Flow	Precipitation	ETR	Temp.	Flow	Precipitation.	ETR	Temp.
DEF					**MAM**			
Flow	1.00	0.08	0.03	0.03	1.00	0.16	0.16	-0.15
Precipitation	0.08	1.00	**0.91**	-0.03	0.16	1.00	**0.94**	-0.06
ETR	0.03	**0.91**	1.00	0.08	0.16	**0.94**	1.00	0.06
Temperature	0.03	-0.03	0.08	1.00	-0.15	-0.06	0.06	1.00
JJA					**SON**			
Flow	1.00	0.25	0.21	-0.21	1.00	0.42	0.38	-0.17
Precipitation	0.25	1.00	**0.97**	-0.15	0.42	1.00	**0.91**	-0.15
ETR	0.21	**0.97**	1.00	-0.07	0.38	**0.91**	1.00	0.07
Temperature	-0.21	-0.15	-0.07	1.00	-0.17	-0.15	0.07	1.00

Precipitation: Precipitation, ETR: Real Evapotranspiration, Temp. Temperature. Source. Authors Elaboration.

Linear multivariate statistical model was contextualize in terms of flow as a dependent function of the precipitation, the ETR and temperature, as shown in equation 4.

$Q = f(P, ETR, T)$, (Equ. 4),

where Q represents the flow in m^3/s, P corresponds to the precipitation in mm, ETR is the real evapotranspiration, in mm, and T refers to the temperature in °C.

To obtain the model it was working with the registers of 46 years (1970-2015) of each of the variables mentioned above, and product-moment multiple correlation of Pearson (Table 7) was calculate. In this case, $p \geq 0.70$ indicates that the variables are correlate directly. Thus, the results in table 15 show in all climate periods, a significant direct relationship of precipitation with ETR (higher values to 0.90).

Given the above, it raised the multivariate linear statistical model using Equation 5, whose response variable is the flow and the explanatory variables: precipitation, temperature and ETR.

$Q = x_1 P + x_2 ETR + x_3 T + e$, *(Equ. 5)*

where x_1, x_2, and x_3 represent the regression parameters, and e the error associated to the regression. The obtained results are present in Table 8.

Table 8. Results of regression parameters for each of the climatic periods.

Variables	DEF	MAM	JJA	SON
Precipitation	0.006298	-0.0011553	0.01322	0.008968
ETR	-0.012884	0.01092	-0.020417	0.017004
Temperature	0.070087	-0.16077	-0.20586	-0.28865
Error	0.15991	4.2321	6.6158	6.1497

In this way from Table 8, regression models that could support making decision for the granting of water in each climate quarter were raise. Therefore, the CMDB would have the tool to check the amount of flow available in terms of the seasonal variations owner of the Colombian Andes Region.

$Q_{DEF} = 0.006298P - 0.012884ETR + 0.070087T + 0.15991$, *(Equ. 6)*

$Q_{MAM} = -0.0011553P + 0.01092ETR - 0.16077T + 4.2321$, *(Equ. 7)*

$Q_{JJA} = 0.01322P - 0.020417ETR - 0.20586T + 6.6158$, *(Equ. 8)*

$Q_{SON} = 0.008968P + 0.017004ETR - 0.28865T + 6.1497$, *(Equ. 9)*

The regression models built, collect the historical memory of climate change and respond to the input data delivered in this case by the CMDB and IDEAM. So in its construction could be committing errors of judgment, but not procedural associated with the uncertainty of them. However the CMDB would be able to verify and implement through the established network monitoring a better management of them.

DISCUSSION

The inadequate practices of management water resources that carried out in the basins, determined by the ratio supply-demand, demonstrate the reality of facing immediately the problems associated with the conservation and preservation of them (2 ,31,1) . Based on the above, advanced societies in environmental terms are increasingly demanding a water management more respectful of the natural environment, enable the enjoyment of intrinsic values increasingly appreciated, as the ecological, cultural, esthetic, sports and recreation (2,6). In this sense, it is necessary that water management is addressed with an integrated approach of its two facets like water reserve and environmental (1,9,32); with this premise, the implementation of an environmental management watersheds must be based on flow regimes (33,31) and the risk they represent on communities (34) .

Therefore, knowledge of the flow regime constitute a fundamental tool in watershed management plans, because they enable water management in a rational way, tailored to their different uses that preserve the functionality of the river ecosystem (31,1 , 9). Of this mode, for the basin under study data having influential variables as rainfall and temperature can be determined the effect of supply over demand in the sub-basin, and thus know the real possibilities of granting flows. Especially if you consider that there should be an ecological flow that meets the needs of human supply and agricultural and industrial supply (31,35,36).

They found more than 80% of the data flow are minor than 2.23 m^3/s, although there are above the ecological flow of 0.090 m^3/s reported by the CMDB for 2004. This is to clarify that this is the source of supply of urban aqueduct of Piedecuesta (Santander), and for that same year the authorized concessions were 0.528 m^3/s being available 0.411 m^3/s, which results are not enough to meet the demand of the urban population header projected for the year 2022 at 0.625 m^3/s (28). This shows the urgency of implementing a water system planning adjusting to the real context.

In Colombia (32) according to the Article 21 of the project of law of the water, IDEAM design the particular guidelines for calculating the ecological flow, and is based on a hydrological process with a very simple design of the river, considered as ecological flow "... the permanence value in the source during the 90% of the time ...". For that, it was establish three methods: The 90th percentile curve duration, recurrence of 2.3 years, or the approximate percentage of 25% of the multiyear lower monthly average flow.

However, in practice the fixing ecological flow is done based on two types of criteria (32):

a) Analysis of Regimes Historical flows: Study especially periods of natural low water levels of the rivers, under the conception of those river communities have evolved subject to certain types of flow regimes, and thus their life cycles and ecological requirements are adapted to the seasonal variations owner of that regime.

b) Analysis of Variance habitat with circulating flows: Developed long time ago (35,37), is based on the RHABSIM methodology, and the use of it is widespread throughout the world. The conceptual basis of this methodology lies in knowing the circulating flow requirements of some species, or certain reofilas communities and their distribution in time, able to assess the flow requirements in order to maintain their populations.

Some basic ecological flows are obtained with any of the above criteria, variously known (minimum, desirable, optimum, of maintenance) according to the method used for its calculation, or level of ecological requirement. These flows represent estimates of the boundary conditions of tolerance to low flow, or thresholds community resilience (36). So, if the CMDB have a network monitoring more efficient that not depend on contractual processes operators, which will also increase the number of these considering each micro basin for their location, optimization and data quality obtained with a frequency collection increase to define collection process with results closer to the reality of each study area.

Therefore, activities in the planning processes should be the primary tool to implement, aimed at building processes, where the primary goal is preserving and make a comprehensive management of water resources, as recommended by García *et al.* (6) and Sedano-Cruz *et al.* (34) , who mentioned that in Colombia, it is necessary to strengthen the Integrated Risk Management in the management of land and water resources by the environmental authorities.

Given the influence that rainfall has on the behavior of flows (38,17) , coinciding with the four climatic seasons dominate in Colombia (14) , is posed a structure analysis which is an incorporation of climate information in management systems. For example, a lag of one month between the occurrence of the peaks of flow and when the rainfall occurs, as happens for the Cauca River (39,40).

Also it find an association between negative anomalies (positive) and the occurrence of El Niño (La Niña), it is feasible to decrease (increase) the flows by direct influence of macroclimatic event (14,17) . Relationship between years of El Niño and La Niña with flow has also been reported by Mesa *et al.* (14), Poveda (17) and Poveda *et al.* (15) , and it is the system response to ocean-atmosphere coupling (41,42) .

Despite the uncertainty on information currently available from the Corporations and IDEAM, wave the need to create policies that allow to give immediate responses to the water resources affectations(6,43) , therefore, the importance of interpreting these statistics from the context of climate variability, allows increase its functionality in making decision, for a variety of opportunities ranging from recognize the periodic fluctuations of the climate system and how can be the tool to predict restoration actions, maintenance, conservation and planning control.

The evaluation of the sub basin from the hydrological balance (44) determines the knowledge of all stakeholders, but especially the behavior of precipitation, the ETR and temperature to understand hydraulic runway. For the case study corresponds to a watershed, which aims should be collecting water from different sources of precipitation and at the same time generate water discharge as runoff, to ensure sustainability of the resource.

CONCLUSIONS

Test results obtained in the flow analysis of the middle and upper basin showed that seasonal and interannual variability through migration of ZCIT, dominates the precipitation and affects the flow regime of subbasin. Once do, taking into account the availability of water resources and that the location of the cities creates a pressure on it, verification of ecological flow becomes an obligation that must be monitor in the lower basin.

It was evident as precipitation responds to the seasonal and interannual variation scales and its direct effects on flows. Through the identification of climate quarters it is necessary, in territorial planning processes, include climate variability as a conditioning tool of the environmental systems, formulated and applied as instruments management by the Corporation.

Seasonal and interannual variations in temperature has a direct relationship with rainfall and water flows, during the first half of the year, possibly associated with the type of convective precipitation, which is depends on the heating produced throughout the day in a given area in the troposphere. Meanwhile, as shown in the second half of the year may be a response of direct influence of the ZCIT and orographic precipitation.

System Environmental Management of CMDB forming as a result of the compendium of standards and adaptations of instruments at the national order, has been generated as individual efforts tending to meeting targets, without a representation according to the reality, that is, the regional activities in the Planning Process respond more to natural, water and geomorphology dimensions of the region, and not to natural climate variability, that should be the principal tool applying, aimed at building processes, where the important goal will be to preserve and do an integrated management of water resources, for this case Rio de Oro subbasin.

Regression models built respond to input data delivered in this case by the CMDB and IDEAM, so in its construction could be committing judgment but not procedural errors, associated with the uncertainty of them; however, the CMDB would be able to verify and implement across the established network monitoring a better management of them.

The consideration of the Environmental Management System based on climate variability allows better manage of the water resources, in this regard for Rio de Oro sub-basin, it proposes a review of the current planning instruments and the implementation of the Statistical Model to help in water concession process associated with the availability of natural resources.

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