ENVIRONMENTAL FLOWS

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1. Introduction

In addition to human beings a lot of other life is dependent on the water in the river. Abstraction of too much water from the river (*how much is "too much"? Read on*) is detrimental to the sustenance of aquatic flora and fauna. Therefore a certain minimum flow has to be maintained in the river for sustenance of aquatic ecosystems. Accordingly, thinking on river ecology started on the concept of a "minimum flows" which refers to a certain minimum flow that must be maintained in the river for the survival of aquatic flora and fauna, and for the sustenance of the aquatic ecosystems. However, gradually it was realized that preservation of aquatic environment requires not only a certain minimum flow, but also certain water quality, temperature, velocity, periodic flushing pulses of high flows, - in general a complete flow regime. Therefore, over the past few years the term "minimum flows" has been discarded in favour of a more general term **E**nvironmental **F**lows (EF) or **E**nvironmental **F**lows **R**equirements, (EFR). Thus, while minimum flows referred only to the quantity, EFR refers to a complete flow regime.

The need for EFR has come to the fore only recently after the abstractions in certain river reaches increased to a point where it started harming the aquatic ecosystems. Simultaneously, the awareness and concern about the health of the environment became accentuated. There has been considerable debate on the issue of minimum flows during past few years. However, no satisfactory solution has emerged to remove the difficulties in implementing EFR and improve the health of river ecosystems.

2. Problem Definition

No reasonable person would deny the need to preserve aquatic ecosystems. The problem is, in many basins the requirement of water by the mankind is so large that almost no water is left for the EFR. In India, this happens to be the case in almost all the river systems with the possible exception of certain rivers in the north eastern region. This is the scenario when the total water utilization is just about 650 bcm. Therefore the scenario will only be worse when the utilization reaches its full potential of about 1122 bcm. But utilizing that much quantity of water, perhaps more, is unavoidable. Producing about 500 MT of food grains for a projected population 1600 M by 2050 requires more than 900 bcm of water for agricultural use alone. And, as shrinking land holdings and increasing population forces more and more people to turn away from agriculture and find employment in industry, the industrial use will also increase. And of course the domestic use will increase due to increasing population, and also increasing urban population.

All this brings EFR in a perpetual conflict with the water requirements for all other uses - irrigation, hydropower, industry, and drinking water requirements. We all want the aquatic flora and fauna to survive. But we also want ourselves to survive. However, the public discussion space is dominated by those are not required to prove that what they advocate is workable. As a result no satisfactory *and workable*[1] solution has yet been found to resolve

[1] Note the stress on "workable". Romantic, unworkable solutions are aplenty.

this conflict. As the population increases, and the requirement of water for various uses by the mankind further increases, the conflict is destined to get even more difficult to resolve.

Before proceeding further, it would be useful to note that only the aquatic ecosystem has a claim on river water. Terrestrial ecosystem can not have any claim on the river water. As the rain falls on the land areas, terrestrial ecosystems takeaway their requirement and only the balance (if any) reaches the river. The river represents the lowest point in a cross-section and if there was no mankind, (*which, according to environmentalists, is the ideal state from environmental considerations*) water in the river can not return to the land, and can never be available to the terrestrial ecosystems. Under the natural conditions, water that reaches the river is permanently lost to terrestrial ecosystems. Therefore any debate about the needs of the ecosystems in the context of river water must refer only to the aquatic ecosystems.

3. National Water Policy and EFR

The **N**ational **W**ater **P**olicy (NWP) of India stipulates (Clause 14.3) that "Minimum flow should be ensured in the perennial streams for maintaining ecology and social considerations." However, the NWP also places environment in the fourth order of priority for allocation of water. The priority sequence is 1: drinking water, 2: irrigation, 3: hydropower, and then 4: environment. The normal meaning of this would be that of all the available water at any location, first the requirement for the drinking should be supplied. From the balance (if any) requirement of irrigation should be supplied. From the balance (if any) requirement for hydropower should be supplied. And then from the balance (if any) requirement of the environment should be supplied. On the other hand, the concept of a minimum flow in the river stipulates that a certain quantity of water is to be first allocated to maintain this minimum flow, and all other requirements are to be supplied only from the balance (if any). This upgrades the environment's requirements at priority # 1. Thus it would be seen that placing of environment at fourth priority in the NWP creates a conflict with the very concept of minimum flows or EFR.

It may also be noted that Clause 14.3 stipulates minimum flows only in *perennial* streams. This should be obvious. If a stream under natural conditions goes dry in certain parts of the year, then it would be going against the nature to make water flow in it round the year.

4. Quantifying EFR

Even if it is accepted that the order of priority stipulated in the NWP is to be interpreted differently, and a certain minimum flow is to be maintained, there are some practical difficulties in planning for EFR. The first and foremost problem is quantifying the EFR.

Sometime around the year 2000 the global debate on the minimum flows/ EFR divided the uses of water into three groups.

1. Drinking water requirement - which was called "**water for people**".
2. Irrigation requirement - which was called "**water for food**".
3. Ecology's requirement -which was called "**water for nature**".

The use of ornamental phraseology, and also from the fact that water requirement for hydropower and for the industry was ignored as if no such thing exists, it is obvious that the debate was dominated by environmentalists.

The next step would be to quantify these requirements so that appropriate allocations are made from the available river water. "Water for people" is easily quantified. There are agreed norms for the domestic water requirement in liters per capita per day. Multiplied by the expected population, the "water for people" requirement can be quantified.

“Water for food” is also easily quantified. The quantity of water required for growing a unit quantity of any given crop is known. Based on population projections the requirement of various agricultural products can be estimated, and from these the water requirement for agricultural purposes is quantified.

But quantification of “water for nature” poses a formidable problem. Even at its simplest level, this is the quantity of water required for preserving various life forms in the river. The rational way to estimate this would be by mapping ***all*** the aquatic flora and fauna in a given reach of the river, studying their life cycles and water requirement during various stages of life, etc. But there are several problems with this approach.

- Though it sounds simple, in reality this kind of study is an extremely complex exercise that demands a lot of time, efforts, and resources. It is very difficult to carry out such a study for every reach of every river. To the best of knowledge of the present author, such a study has not been completed for *any* river *anywhere in the world*.
- Preservation of aquatic life requires not only a certain minimum flow but also requires various water quality parameters, water temperature, turbidity, and the velocity of flow to be within certain limits. It is extremely difficult to even determine all these requirements, far less comply with them.
- Different life forms tend to develop for every environmental niche. If the river flows to a very high level for just a short duration in a year, there would be some life forms that flourish only under those specific flow conditions, for that part of the year. If every life form that exists in a river reach is to be preserved, that would mean restoring the *pristine flow conditions*, i.e. no abstraction whatsoever from the river. This is clearly impossible. But permitting any abstraction from the river amounts to consciously accepting that some life forms may not be preserved. This is absolutely unacceptable to the environmentalists.

5. Empirical methods for quantifying EFR

In the face of worldwide failure of the so called rational method for quantifying EFR, many researchers have proposed arbitrary guidelines for quantifying EFR. These link the minimum flow to some % of the mean annual flow (MAF), or 75% dependable annual flow, in the river. e.g. a minimum flow of 2.5% of the mean annual flow, to be maintained throughout the year; and a flushing pulse of 250% of the mean annual flow, to be provided at least once during the year.

> **Example :** Mean annual flow in volume units at a certain location is 16 bcm. 2.5% of this is 0.4 bcm. This volume evenly distributed over the year is $0.4*10^9/(365*24*3600) = 127$ cumecs, which is the minimum flow to be maintained throughout the year.
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> Likewise, 250% of the mean flow = 12,700 cumecs. So, one flushing pulse of 12,700 cumecs should flow through the river once a year. (*duration of the flushing flow is not stipulated*).

These are often called empirical formulae, but that is an incorrect description. An empirical formulae establishes a relationship between two or more quantities. e.g. Manning’s formula computes velocity as a function of channel parameters. The “2.5% of MAF” does not say what exactly will this minimum flow accomplish, what life forms will survive and which ones will not, etc. If a question is asked why 2.5% of MAF, mean annual flow, why not 2.4%, or 2.6%, there is no answer. Therefore, these are merely “arbitrary recommendations”.

6. Modified Tennant’s Method

Of all the “arbitrary recommendations”, the modified Tennant’s method is the one quoted most often. This “method” indicates, in descriptive terms, the likely status of the habitat for various levels of EFR in two six monthly groups. The modified Tennant method table is given below.

[**Source** : *Establishing Environmental Flow Requirements, Synthesis Report, by Dave Maunder, Brian Hindley, and others. Downloaded from internet*].

Narrative Description of Flow	April to September	October to March
Flushing flow (from 48 - 96 hours)	200% MAF (Mean Annual Flow)	Not Applicable
Optimum range of flow	60 - 100% MAF	60 - 100% MAF
Outstanding habitat	60% MAF	40% MAF
Excellent habitat	50% MAF	30% MAF
Good habitat	40% MAF	20% MAF
Fair or degrading habitat	30% MAF	10% MAF
Poor or minimum habitat	10% MAF	10% MAF
Severe degradation	<10% MAF	<10% MAF

What this means is, if the quantity of water basin managers can provide for EFR is ≤ 20% of MAF (10% during April to September and 10% during October to March) then the environmental quality of the habitat in that reach will be “Severe degradation”. And if a “Good” habitat is desired, then at least 60% of the MAF must be allocated for EFR, 40% during April-September and 20% during October to March. These requirements are so absurd, that no further comments are required for any one having slightest familiarity with the water availability and water requirement in typical Indian basins.

7. Problems with Arbitrary Recommendations

There are two main problems with such arbitrary recommendations.

a) It fails to take note of the difference between releasing a certain flow in the river at control point, and having that much flow throughout a given reach. Suppose the MAF in a certain basin outfall is 16 bcm, and it is agreed to allocate 20% of this during October to March, hoping for a “Good habitat” as per above table. 20% of 16 bcm = 3.2 bcm. Distributed over Oct to March, this = $3.2*10^{9}/[(31+30+31+31+2831)*24*3600]$ = 203.5 cumecs. Accordingly, 203.5 cumecs will be released / allowed to flow in the river at the control point - i.e. a dam or a barrage. But that does not mean the flow will be at least 203.5 cumec in the reach thereafter. Very likely, most of it will be lost to evaporation and percolation within a few kilometer, and the river thereafter will be dry or close to dry. Which means, despite allocating a hefty 20% of MAF for EFR, most of the reach will still have very little flow, and appropriately degraded quality.

Amazingly, the global debate on EFR continues to fail to take note of the difference between allocating a certain volume for EFR and releasing the corresponding flow in the river at control point, vis-à-vis maintaining a that flow throughout the river in a

given reach. This is perhaps one of the best examples of what happens when those who do not have the necessary theoretical background in hydraulics and hydrology are elevated to the status of "experts".

b) Since it does not establish any relationship between the EFR and exact ecological gains, a significant quantity of the yield of the river is allocated away without ever knowing exactly what purpose it will serve.

8. Impact of EFR on the water budget of a river basin.

The basic water budget for India is well known, but is reproduced below for ready reference.

Total Precipitation	4000 bcm
Annual Fresh Water Resource	1869 bcm
Annual utilizable fresh water from surface water sources 690 bcm	
Annual utilizable fresh water from ground water sources 432 bcm	
Total Annual utilizable fresh water 690 + 432	1122 bcm

Different agencies have assessed the total water requirement for the year 2050 and all these estimates are a little less than or a little more than the availability of 1122 bcm. If Indians want their rivers' habitat quality to be just "Good", then as per modified Tennant method, 40% of 1869, or 748 bcm of water must be allowed to flow in the rivers as EFR. The readers can judge for themselves what this would do to the national water budget, and agriculture.

9. Justifying EFR

All water allocation decisions involve a tradeoff between volume of water allocated and benefits for each competing use. Each claimant for water has to justify its use in terms of quantified benefits. Till recently, the competing users used to be either political/administrative entities – like different states or nations; or they used to be different sectors – like domestic use, irrigation, industry, hydropower, etc. Now, with increased awareness about the environment, one more competitor has been added to the field. But the NGO saviours of environment are yet to grasp the fact that environment is also one of the competitors for water (and no more) and therefore will have to plead its case logically, quantifying the benefits vis-à-vis quantity of water allocated. Instead, the case for environment is sought to be pleaded on a self-righteous note, as if it is blasphemous to question the benefits from EFR. Snide comments such as "*farmers have votes, fishes do not have votes*" may help one earn some brownie points in seminar halls, but these are of little value in the field, as the case study of Keoladeo National Park shows.

10. Not a "minimum flow", only a "minimum release".

If there is no man-made abstraction structure on a river, the natural flow regime prevails. Thus, the question of "maintaining a minimum flow" arises only when an abstraction structure is built across the river and the natural flow regime is modified. Maintaining a minimum flow in a given reach would mean - if a discharge observation is taken at any point in that reach, the flow should never be less than the stipulated minimum flow.

However it would be very difficult to implement a minimum flow by actually setting up a series of GD sites along the river, and continuously modifying release decisions based on the real time flow data received from these GD sites. In practice, minimum flow can only be implemented by computing possible losses in the stipulated river reach, and releasing the stipulated minimum flow plus the expected losses, at the control point. Often, this may not necessarily ensure the stipulated minimum flow, because of unexpected losses, even direct abstraction from the river by the farmers.

Going a step further back, the flow in cumec to be thus released at the control point is converted to a volume for the entire year, and that much water is kept aside while allocating the water to other users at the control point. Very likely, such allocations will be formalized through inter-state MoU or even a Tribunal Award. In a water scarce basin, even in a society where environmental consciousness is very acute, EFR is most unlikely to secure an allocation of 40% of the MAF during monsoon season, and 20% of the MAF during lean season, which is the requirement for a "Good" habitat as per modified Tennant method. Insistence on such allocation for EFR can only result in a deadlock. Typically, a much smaller quantity gets allocated for EFR. Over a period of time, it is realized that this has no beneficial impact on the environment. Protagonists of environment do not seem to realize that once the allocations are formalized through an MoU or Tribunal award, these can not be altered through an Executive order. Thereafter, all that remains is - the activists keep berating the Government for "killing the river" while a certain quantity of water continues to get released in the river as if it was a ritual, with no reference to what does that achieve.

11. Reality of More EFR

The case of Bharatpur Bird Sanctuary, also known as Keoladeo National Park, is a good example of why it is not easy to achieve Tenant's "Good Habitate". Keoladeo National Park, a world heritage site and a Ramsar site, is facing a crisis of accute water shortage. The park receives water from Gambhiri river. Farmers in the area have taken to agitation to prevent water from the upstreme Panchna dam to be released for environment.

Water crisis threatens national park

While schemes to provide water from the Panchna dam came to naught, efforts are on to save the park, which is a world heritage site.

JAIPUR, DHNS:

The Tourism and Wildlife Society of India (TWSI) has reiterated the need to save the world famous Keoladeo National Park at Bharatpur, which is facing the threat of extinction, following an acute water crisis.

Asking the state government to shoulder its responsibility in ensuring "free flowing water" to the park, nature lovers joined hands in pressing the need for conserving one of the finest aquatic bird parks in the world, which is also a Ramsar site.

The problem arising due to the discontinuance of water from the river Gambhiri— following the construction of Panchna dam— acquired serious proportions last year, following a farmer's agitation in Karauli not to release water to the park from the dam.

In the news item in the box, the environmentalists have asked the State Government "*to shoulder its responsibility in ensuring 'free flowing water' to the park*". Note the phrase "free flowing water", which not only disputes allocation of water for farming, but also insinuates a challenge to the dam upstreme. The environmentalists can take such a position because they do not have any responsibility towards farmers. But the famrers' agitation took a violent turn, and water could not be released for the park. The moral of the story is, any formula that computes the water needs of the environment without taking into account the needs of the human beings, is unlikely to succeed.

12. Who pays for EFR ?

Water stored in a dam is allocated to various users, like irrigation, hydropower, and the cost of the dam is apportioned amongst these users, in rough proportion to the quantity of water allocated to them. In the normal course, all the water stored in the dam is thus allocated, and all the cost of the dam is apportioned. If any part of the storage is earmarked for environment, then the question arises who (which department) pays for it.

Distributing the cost to irrigation and hydropower, the two largest users, would increase the price of electricity and of irrigation water. That would in turn increase the prices of industrial goods which are heavily dependent on electricity, and also the prices of agricultural produce, which are usually administered prices. These price increases have profound impacts on the economy of the nation.

13. Summary.

Minimum flows, also called EFR, refer to a certain minimum flow that should be maintained in a river reach for protecting the aquatic habitat. While there is no argument about the importance of preserving aquatic eco-systems, there isn't much progress towards making allocations for EFR. It is difficult to quantify the EFR. Rational methods by mapping the aquatic flora and fauna demand huge efforts and resources. Arbitrary stipulations do not clarify exactly what benefits will be achieved in return for the water allocated for EFR. Also, for achieving a reasonably healthy habitat, the EFR works out to such a large quantum that it is impossible to provide it. Past experience indicates that allocations for EFR ignoring the human demand remain on paper, and do not get translated into practice.

In a water stressed basin, the term "minimum flow" is a misnomer. Water allocations are made at the control point on the river and environment also emerges as just one of the claimant for river water, so that the engineer in charge of the control structure can release in the river the quantity of water allocated for environment. In a water stressed basin, where use of water is closely linked to earning of livelihoods and poverty alleviation, allocation for environment will also have to be secured by logically arguing the case for environment, justifying the benefits. Finally, like all other claimants, those arguing the case for environment will also have to learn to accept compromises.