4.3. Irrigation supply and demand modeling

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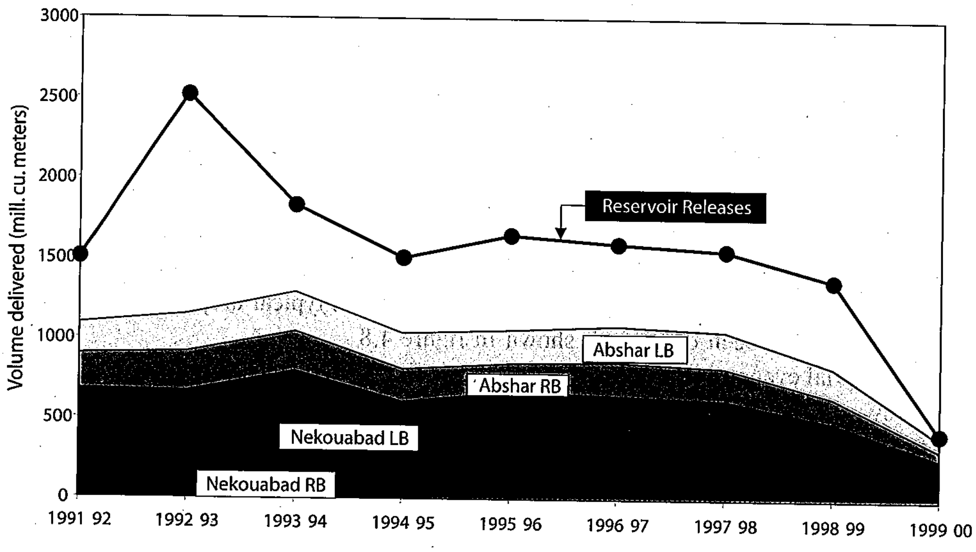
In this paper, attention is focused on the performance of 4 irrigation schemes, namely Nekouabad Right and Left, and Abshar Right and Left, which have been in operation since the 1970s. The Borkhar, Mahyar and Rudasht (East and West) systems, parts of which are still under development and have only just begun to benefit from Zayandeh Rud surface irrigation water, have not been included in this analysis.

4.3.1. Estimating supply to irrigation systems

From the supply side, the calculations are based on the releases made from the Chadegan Reservoir into each of the main irrigation systems. The overall pattern of water deliveries to each system is shown in figure 4.7, from which it can be seen that apart from recent drought years, there is little overall variation in water deliveries from year to year. This is consistent with the overall basin level management that reservoir releases are directly linked to irrigation and other demands based on storage at the end of March, and only in flood years such as 1992-1993 are releases significantly different from average.

Figure 4.7. Releases from the Chadegan Reservoir and issues to four major irrigation systems, Zayandeh Rud basin, 1991-2000.



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4.3.2. Estimating demand for irrigation water

Estimating demand is much more difficult because cropping data is reported by district level only, and these do not coincide with irrigation system boundaries. Attempts to use detailed village cropping data were abandoned because it requires a large amount of data processing and transformation, and a trial effort resulted in major data inconsistencies.

Transforming district level data to irrigation system level data was undertaken on the basis that essentially all cropped areas would be irrigated, and that there is little significant variation in cropping patterns within a district. There are eight districts in the irrigated part of the basin, and by assigning irrigated areas on a proportional basis, the overall cropped area for each basin was developed, as shown in table 4.3.

Table 4.3. Summary of annual crop areas obtained from district-level statistics.

Year	Nek LB	Nek RB	Abs LB	Abs RB
1991-1992	37,395	14,931	28,360	12,199
1992-1993	39,029	14,948	31,596	13,591
1993-1994	39,765	15,270	27,647	11,892
1994-1995	40,141	15,203	27,172	11,688
1995-1996	39,828	15,002	28,023	12,054
1996-1997	38,694	14,619	29,677	12,766
1997-1998	28,699	14,685	29,612	12,737
1998-1999	27,268	13,956	26,550	11,420
1999-2000	21,669	11,376	21,612	9,296
Average	34,721	14,443	27,805	11,960
C.V. (%)	20.0	8.4	10.0	10.0
Crop Intensity	0.72	1.07	1.85	0.80

The district level data identify in excess of 40 crops. To simplify calculations, major crops were identified, together with their normal growth period so that overall estimation of demand could be determined on a monthly basis. From this, a typical cropping calendar for the Zayandeh Rud has been developed, shown in figure 4.8

The potential evapotranspiration of the 10 crops chosen to be representative of the more than 40 grown in the basin, were estimated using the FAO-CROPWAT program. The data records for the Kabutarabad meteorological station were used for this purpose. The crop water requirements thus obtained were then applied to the estimated crop areas and cropping patterns to determine the water demands of each of the 4 irrigation systems for the 9 years being studied.

Figure 4.8. Typical crop calendars, Zayandeh Rud basin.

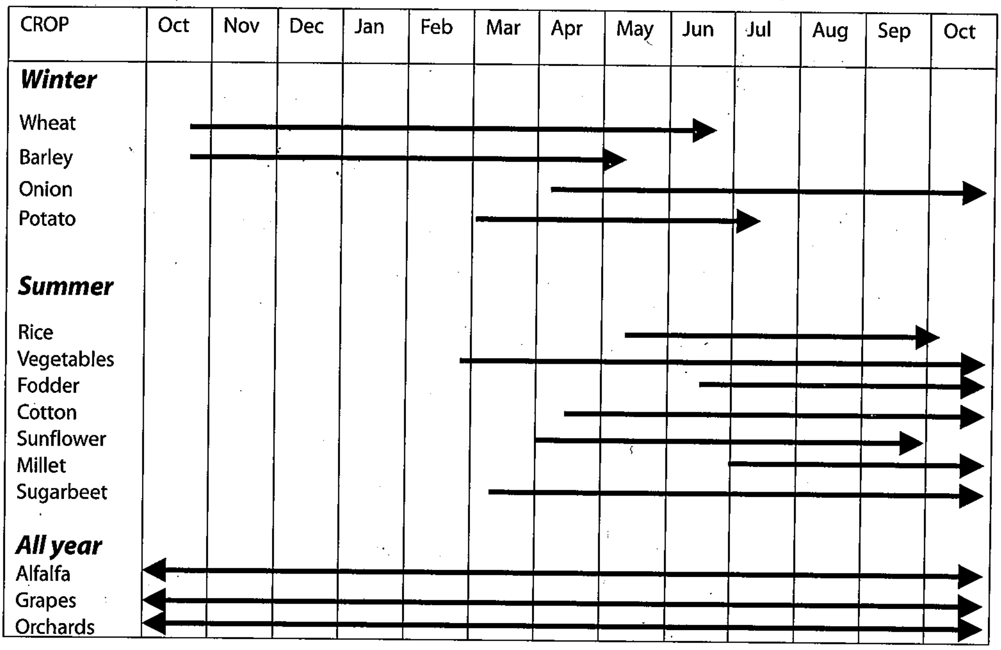
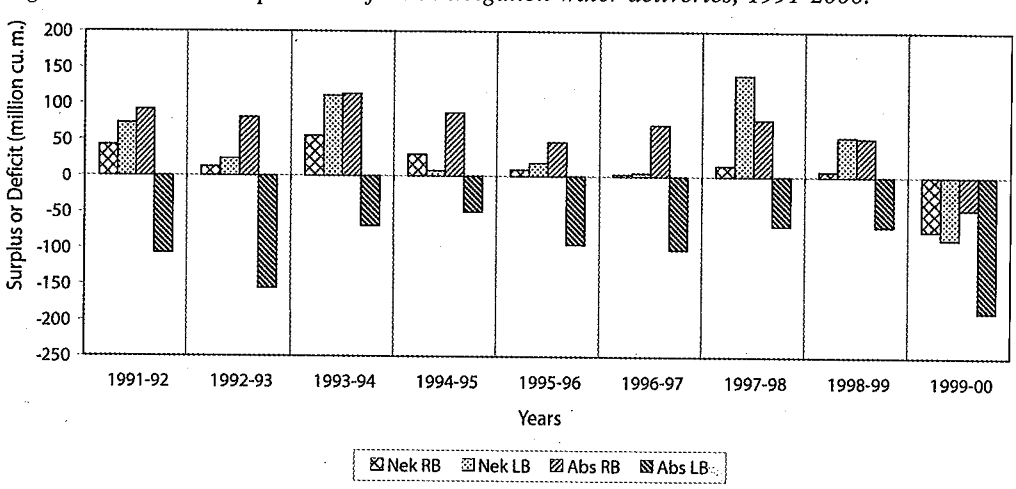


Figure 4.9. Annual surplus or deficit in irrigation water deliveries, 1991-2000.



This approach enables a direct comparison to be made between the overall supply in terms of canal irrigation and the potential demand for water. If there are shortfalls in water supply, actual evapotranspiration will clearly be less because crops cannot transpire at their full potential.

Comparison of supply and demand can be done either on an annual or a monthly basis. On an annual basis, it appears that there is a very consistent pattern over the past 9 years (figure 4.9). Three of the four systems show an overall surplus of water delivery over supply, while the Abshar Left Bank shows a consistent annual deficit.

Overall, the entire basin has been more or less in balance for the four systems. Only in the drought starting in 1999-2000 did all systems show an overall water deficit, but before that there were 5 years when deliveries exceeded overall demand, and 3 years when deliveries were less than total demand. On average, there has been a slight over-delivery of water into each system but it does not seem to be very high, and indicates that at least on an annual basis, supply and demand are relatively well matched. Annual calculations, however, mask the pattern of monthly deliveries, which require a more detailed analysis.

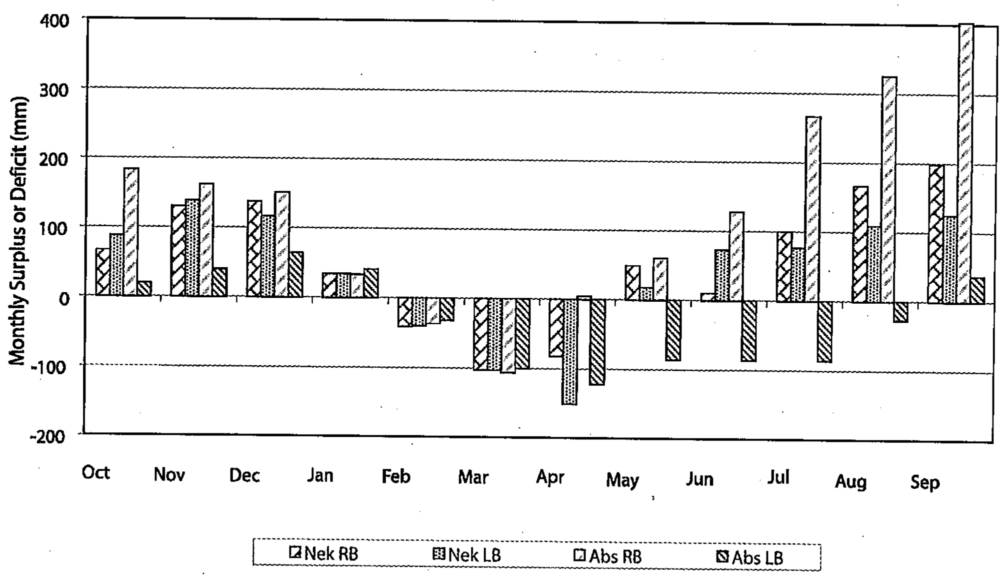
To demonstrate the importance of monthly deliveries, 2 years have been selected as examples: 1991-1992 as a normal year, and 1999-2000 as a drought year (figure 4.10). The monthly estimates of supply and demand show that large differences occur within a year. In the typical year of 1991-1992, water deliveries are in deficit for the period February–April, reflecting the closure of the Chadegan Reservoir from January to March each year. The deficits are significant in both March and April as temperatures increase after the winter, and farmers must either rely on stored soil moisture or resort to groundwater pumping to get crops established. From May onwards, however, supplies increase and there is surplus in all systems except Abshar Left Bank up until the end of August. From September until January, all systems receive more water than is required.

By contrast, the situation in the drought year of 1999-2000 shows a deficit from January through September. In order to get any form of yield, farmers had to resort to intense groundwater pumping and this was instrumental in leading to a marked decline in groundwater levels during this period. The situation must have been made worse in 2000-2001 when no releases were made for irrigation, and all agriculture depended entirely on groundwater.

From these results, we can conclude that there may well be opportunities for fine tuning irrigation deliveries during crop seasons in order to avoid excessive surpluses and deficits between different parts of the system. Changing the rule curves for dam operation to store more water into late spring and summer may help, but system operators also need far more knowledge of groundwater-use within systems than they currently appear to have.

Figure 4.10. Monthly water surplus and deficit in four irrigation systems under normal and drought conditions.

a) Normal Conditions (1991-1992)



b) Drought Conditions (1999-2000)