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SUMMARY - This paper has been prepared to display parameters which are used to determine the site selection of aquaculture facilities in Turkey. The Ministry of Agriculture and Rural Affairs has developed the parameters in the last three decades. During this period total farmed fish production has risen from almost nil to 33,200 ton/year. In this development, its own experiences and international experiences of foreign consultants, whose assistance was provided through the project managed by the World Bank and financed by the Government of Japan, have been utilized. At the present moment, the following parameters are considered in site selection: temperature range, salinity, areas of ground and surface and water depth, type of ground, tidal range, elevation and distance from the sea, distance from land, nature of seabed, type of pumping system, coastal topography, shelter, access, services, local infrastructure and hazards. During this survey project which was undertaken in 1993, 104 sites along the Turkish coasts were identified and have been utilized. Since it has a quite long coastline (8333 km), Turkey has the potential to expand its sites with the development of technology (offshore cages). Inland aquaculture sites are locally surveyed by the provincial staff of the Ministry using similar parameters. Inland aquaculture of Turkey with its 33 rivers, several streams and dam lakes (43 are open to aquaculture) is promising.

Key words: Aquaculture, Turkey, site, selection

RESUME *- "Sélection du site. Le cas de la Turquie". Cet article a pour propos de montrer les paramètres qui sont utilisés pour déterminer la sélection du site pour des exploitations aquacoles en Turquie. Le Ministère de l'agriculture et des affaires rurales a mis au point ces paramètres sur les trois dernières décennies. Pendant cette période, la production piscicole totale est passée de presque rien à 33200 tonnes/an. Pour ce développement, il a eu recours à sa propre expérience ainsi qu'aux expériences internationales de conseillers étrangers dont l'aide est venue au travers d'un projet géré par la Banque Mondiale et financé par le Gouvernement du Japon. Actuellement, sont considérés pour la sélection du site les paramètres de spectre de température, salinité, superficie occupée en surface et sur les fonds marins et profondeur des eaux, type de sol, spectre des marées, élévation et distance de la mer, distance de la terre, nature des fonds marins, type de système de pompage, topographie du littoral, abris, accès, services, infrastructure locale et risques. Lors de cette étude de projet qui fut entreprise en 1993, 104 sites furent identifiés et ont été utilisés le long des côtes turques. Etant donné l'étendue de sa ligne côtière (8333 km), la Turquie possède le potentiel pour augmenter ses sites en parallèle avec les progrès de la technologie (cages en mer ouverte). Les sites aquacoles continentaux sont l'objet d'études effectuées localement par les équipes provinciales du Ministère, en utilisant des paramètres semblables. L'aquaculture continentale en Turquie est prometteuse, avec ses 33 cours d'eau, plusieurs rivières et des retenues de barrage (43 sont ouvertes à l'aquaculture).*

Mots-clés : *Aquaculture, Turquie, sélection du site.*

Introduction

Turkey, with a population of 63 million and a surface of 814.578 km^2 and its favourable geographic position between the Black Sea and the Mediterranean Sea, with 8333 km of coast line has access to the fishery resources of both these water bodies. The country is also endowed with rich inland waters (200 lakes, 159 dams lakes, 750 small dam lakes) and river systems (33 rivers) with significant capture fishery and aquaculture potential. 1996 fish landings, including aquaculture production, show that Turkey, with its annual production of 549,646 Mt. is one of the important fishing countries in the region.

However, the fisheries sector has not reached the adequate level in agricultural and in national economy, yet. Fisheries account for 0,4% of the GNI (Gross National Income).

In Turkey the main species cultured are seabass and bream, trout, carp, shrimp, and mussel and total production is 33200 ton/year from 881 farms. The sector has been supported by the government with 3 research institutes, 8 hatcheries, 80 provincial offices and laboratories and several Universities providing education. The private sector has also developed servicing of manufacturing of feed, material and equipment.

The sector has problems of complex licensing procedure, presence of unlicensed farms, lack of advanced local technology, capital and market.

Site selection is an important factor of aquaculture affecting both general and farm level management; so in order to make proper site selection the following pointa are considered: temperature range, salinity, areas of ground and surface and water depth, type of ground, tidal range, elevation and distance from the sea, distance from land, nature of seabed, type of pumping system, coastal topography, shelter, access, services, local infrastructure and hazards.

Taking the above parameters into consideration several marine and fresh water farm sites have been identified by the Ministry of Agriculture and Rural Affairs.

Brief review of Turkish aquaculture

Present situation

Ministry of Agriculture and Rural Affairs is mandated with the responsibility of managing the fisheries Sector. It interacts with other ministries, especially, with the Ministry of Environment in implementing a healthy development programme.

The Ministry discharges its fisheries development and management functions through three General Directorates. The development of aquaculture activities is incorporated in the programme of Work and Budget of the General Directorate of Agricultural Production and Development; research activities are undertaken by the General Directorate of Agricultural Research; and the health management activities through the General Directorate of Protection and Control. The co-ordination is achieved through annual joint programme development consultations.

The increase in aquaculture production in Turkey has been rapid since the first commercial farms established in the early 1980s. The production in 1996 was 33,200 tons comprising mainly seabream, seabass, trout, salmon, carp, mussel and shrimp (Table 1).

Table 1. Number of licensed aquaculture farms and capacities by 1997, Production by 1996 (Source: Ministry of Agriculture and Rural Affairs)

Species	No. of licensed farms	Capacity of licensed farms (ton/year)	Production in 1996
Trout	629	38120	18510
Salmon	2	1600	193
Carp	97	10710	780
Mussel	8	4750	1918
Turbot	1	200	0
Shrimp	3	470	270
Sea bass & bream	141	11975	11530
Total	881	67825	33201

There has been a large number of licences granted for aquaculture but not all of these have been granted leases or are operational. The majority of the operational farms are small ventures with an annual production less than 30 t.

There are 14 marine fish hatcheries (two operated by the government) concentrating production on seabass, seabream and shrimp producing about 10 million fry of sea bass and bream which is far less than required (50 million) and the rest of fry is collected from wild. There are several private trout hatcheries to supply farms and 5 carp and trout hatcheries of the government for restocking the reservoirs and lakes and for supplying farms.

The procedures for obtaining licenses for aquaculture and for securing leases are complex and are subject to delays. A large number of Ministries are involved with the decision or must be consulted. Licenses for farms smaller than 60 ton/year of capacity are issued by Provincial Offices of the Ministry. Others have to be endorsed at ministerial level.

There is credit incentive with 59% interest rate (inflation rate is about 100% per year) which is provided by the Agricultural Bank.

The Government is active in the encouragement of aquaculture development through the work carried out in the 3 Fisheries Research Institutes (one for fresh water, 2 for marine) and the Government hatcheries. There are a number of Universities actively involved with the training of students in aquaculture at graduate and postgraduate levels.

The national infrastructure at moderate level has already been developed for aquaculture with 5 marine fish feed manufacturers, two university laboratories specializing in fish diseases, manufacturers of fibreglass tanks and wooden, fibreglass and high density polyethylene (HDPE) cages, and representatives of foreign suppliers.

Culture systems

The culture systems practised/recommended in Turkey are similar to those used in other Mediterranean and north European countries. However, in the Black Sea the environmental conditions are unique and new technologies must be developed locally. For this reason the Ministry of Agriculture and Rural Affairs is undertaking a project jointly with the Japanese International Co-operation Agency (JICA) to develop fish culture in the region. A turbot hatchery has been constructed at the Fisheries Research Institute at Trabzon and Japanese and Turkish experts are working for this project.

The recommended (*)/practised (**) culture systems for Turkey are as follows:

(i) Offshore cages for salmon. Development of a submerged cage with small floating cage on the surface widening out to a large rectangular cage below with most part of the capacity below a depth of 1 Sm (*).

(ii) Onshore tank farms. Use of long rectangular raceways (30x3~x1.3 m deep) constructed in concrete with reuse of water by passing it through one series of raceways for re-oxygenation and then through a second and third series of raceway 5 (*).

(iii) Cage Culture for freshwater fishes in dam lakes (*).

(iv) Vallicultura. The enhancement of lagoon fisheries and lagoon aquaculture (*).

(v) Inshore wooden cages in the Aegean. Use of larger (5x5x5 m deep) nets suspended from wooden cages with reinforced corners, moored in groups of 20 (**).

(vi) Large offshore metal cages for the Aegean and Mediterranean. Use of large (15x15x10 m deep) nets suspended from metal cages suitable for more exposed sites (few) (**).

(vii) Onshore pond farms. Use of lined ponds for the culture of fish and shrimp. Ponds measuring 30x45x2 m deep for fish and 45x60x2 m deep for shrimp (**).

(viii) Hatcheries. Marine hatcheries of 750,000 and 2,500,000 fry production per year (more required) (**).

(ix) Tank farms for freshwater trout on streams (**).

Present constraints

(i) There are a number of constraints for the development of aquaculture which are either slowing the potential development of aquaculture or will cause problems if allowed to persist.

(ii) Licensing procedures are complex and lengthy.

(iii) Distances between farms are too small in sheltered bays (should be 1,000 m).

(iv) Length of lease is too short to encourage long-term investment (15 years).

(v) Rents for sea and land areas are too high for small farmers.

(vi) Unlicensed farms are operating without penalty.

(vii) Aquaculture is in conflict with a number of other activities because competition for suitable areas is also a direct conflict: tourism; environmentally protected areas; areas for culture and archaeology; navigation and harbours; recreation and holiday villages, military installations.

(viii) Poor design of salmon cages in the Black Sea.

(ix) Very small wooden cages being used in the Aegean.

(x) Shortfall in the supply of fry: insufficient number of marine fish hatcheries; continued reliance on catching fry from the wild.

(xi) Slow introduction of new and appropriate technology.

(xii) High cost of electricity for aquaculture ventures.

(xiii) High disease risk in the trout farms using same stream area.

Main parameters for marine farm site selection

In 1993 the Ministry of Agriculture and Rural Affairs conducted a survey to determine the potential sites for marine aquaculture farms all over the coast of Turkey.

The selection of suitable sites is critical to the success of both marine hatchery and ongrowing facilities and aquaculture planning and management. Since they use same source of water, any problem occurred in any farm (disease, pollution) has the potential to affect others, even the trade. Therefore parameters given below must be considered in practice and are considered as much as possible. However like many countries, Turkey also has several unlicensed farms (more than 100) and is trying to solve it in co-operation with producers and other related institutions.

Although there are differences between the optimum site parameters for each type of facility, they share a common list of points to be considered.

Temperature range

Temperature Range of the water must be acceptable for the species cultured. Therefore several year records of water must be studied and be considered for selection of species. Unexpected changes in temperature can cause severe economical loses. For instance in early 90 ties the Black Sea water temperature increased to above 22°C which is very rare and many salmon farms, in their early stages of life went to bankrupt. The Temperature Range for the species cultured in Turkey is given in Table 2.

Table 2. Temperature range of fish species cultured in Turkey

Name of fish	Optimum growth temperature	Lethal temperature
European seabass (*Dicentrarchus labrax*)	21-22°C	Min. 1-2°C/Max. 33-34°C
Gilthead seabream (*Sparus auratus*)	20-25°C	Min. 3°C/Max. 34°C
Atlantic salmon (*Salmo salar*)	14-18°C	Min. 1°C/Max. 22°C
Rainbow trout (*Salmo gairdnerii*)	15°C	
Black sea turbot (*Pseta maxima*)	14-16°C	Min. 1-2°C/Max. 28-30°C
Mediterranean mussel (*Mytilus galloprovincialis*)	8-26°C	
Kuruma prawn (*Penaeus japonicus*)	26-28°C	

Salinity

Salinity must also be in the correct range, particularly if one is considering an estuarine site. In many cases it may not have a lethal effect however it may retard the growth and may cause losses in hatcheries at larval stage of marine fish. Euryhaline tolerances for the same species are shown in Table 3.

Table 3. Culture densities of fish species cultured in Turkey

Name of fish	Euryhaline tolerance
European seabass (*Dicentrarchus labrax*)	5-50 ppt
Gilthead seabream (*Sparus auratus*)	5-50 ppt
Atlantic salmon (*Salmo salar*)	32-35 ppt
Rainbow trout (*Salmo gairdnerii*)	very tolerant
Black sea turbot (*Pseta maxima*)	12-40 ppt
Mediterranean mussel (*Mytilus galloprovincialis*)	10 ppt +
Kuruma prawn (*Penaeus japonicus*)	35-45 ppt

Areas of ground, surface and water current and depth (for cages)

Areas of ground (ponds, tanks) and surface (cages) needed must be accurately calculated at the start, with allowances made for future expansion (Table 4). Depth also should be at least 2 times deeper than the height of the cage. Water currents should also be calculated carefully to protect the cages.

Table 4. Fish cultured in Turkey

Name of fish	Density production from ponds, tanks and cages
European seabass (*Dicentrarchus labrax*)	6-8 kg/m^3 from ponds and 15-18 kg/m^3 from cages
Gilthead seabream (*Sparus auratus*)	6-8 kg/m^3 from ponds and 15-18 kg/m^3 from cages
Atlantic salmon (*Salmo salar*)	30 kg/m^3 from ponds and 20 kg/m^3 from cages
Rainbow trout (*Salmo gairdnerii*)	30 kg/m^3 from ponds and 20 kg/m^3 from cages
Black sea turbot (*Pseta maxima*)	60 kg/m^2 tanks
Mediterranean mussel (*Mytilus galloprovincialis*)	
Kuruma prawn (*Penaeus japonicus*)	25 animal/m^2 from ponds

Type of ground

Type of ground should allow development of the full working area needed, including services, with minimal civil and earth-moving costs.

Tidal range

Tidal range is not generally a factor open to much selection, but should be minimal in order to facilitate the design and running of the water pumping system.

Elevation and distance from the sea

Elevation and Distance from the Sea are linked together since both are fundamental to the design and subsequent running efficiency of the pumping system. In general the site should be as low-lying as possible in relation to the sea, provided its drainage channel bases are still higher than sea level at extreme high spring tides. It should also be as close to the sea as possible, provided structural damage as a result of storms is avoided. There may also be a choice of whether the site should be closer to the sea at its water intake, or drainage point.

Distance from land

It should be very much considered for the cost of service to and from the cages. Taking the environmental considerations into account, the cages should be at the closest location to land.

Nature of seabed

Nature of sea bed material is important. A rocky substrate allows the possibility of good anchoring for any pipeline and minimizes the possibility of silty water conditions in poor weather.

Type of pumping system

The cost of water supply is a very important part of production and investment. Therefore the capacity and type of pumping system should be carefully be investigated. The type of pumping system depends upon the nature of the site, but the site might also be selected in order to favour one or other method of pumping. The choice is between land-based suction pumps, submersible pumps offshore, and culvert supply to either type of pump.

Coastal topography

Coastal topography must be considered; it should be possible to site the sea water intakes such that they are unlikely to be polluted by entraining back of the site drainage water. The common solution is that inlets and outlets are spaced as far apart as the site allows, with the outlets downstream of the predominant tidal and/or wind-assisted currents. The use of a physical barrier, such as working either side of a narrow peninsular, is another alternative. This is also considered for land based infrastructure such as feed storage and office. Location of these facilities should facilitate the work, save energy and work.

Shelter

Shelter from the strongest prevailing wind/wave direction is also an advantage even a necessity for traditional inshore farms and land based tank/pond farms and hatcheries from the point of view of integrity of the pumping system, and also water quality. Much of the Turkish coast located in the Black Sea and the Mediterranean Sea are open to waves, therefore much of the cage farms are located in western Mediterranean and Aegean Seas where many sheltered bays exist.

Access

Access to the site by heavy vehicle will be required during construction and subsequently during production operations. Distance from existing roads and suitability of terrain for road building, must be considered.

Services

Services such as three-phase electricity, fresh water and telephones, will all be essential, and the feasibility and cost of obtaining these for the site must be considered.

Local infrastructure

Local infrastructure must be able to provide a workforce of at least an unskilled nature; supplies of bulk feeds for the ongrowing farm must be obtained and stored; specialized equipment repairs and servicing are best done as close to site as possible.

Hazards

Hazards such as known local industry producing toxic waste should, of course, be avoided. Blooms of toxic phytoplankton, "red tides", are becoming increasingly important to aquaculture on a world-wide scale and some consideration should be given to them when siting any new farm.

Main parameters for inland farm site selection

No survey covering all resources of the country has been conducted for this purpose. The following parameters are being used for determining inland aquaculture farm sites. Provincial Offices of the Ministry of Agriculture and Rural Affairs are receiving the project applications and issuing license for farms smaller than 60 ton/year capacity. Applications from bigger farms are sent to the Ministry for approval.

Temperature range

There are two important fresh water fish species for Turkey, trout and carp. Trout (rainbow trout) requires optimum 14-18°C water temperature (WT) for growing and Minimum 1°C / Maximum 26°C WT. may have lethal effect on it. This should be especially considered for cage culture in dam lakes since the temperature of spring waters do not show sudden changes.

For optimal carp growing 20-24°C water temperature is required.

Water quality and source

Water should be analysed for the following parameters; Alkalinity, CO_2 , O_2 level, pH, Ammonia, Nitrate, Cl_2, etc. The result of analyses should be with in the limits accepted for the fish species to be grown.

Carp is more tolerant to water quality than trout.

Water source and flow must also be reliable and should not require pumping (where possible). To calculate the production capacity 1 l/s water flow is required for 200 kg trout/year production, with same water supply, 5-6 t carp/ha/year production should be planned.

Topography

Topography must be considered. It should allow the use of natural flow of water and drainage. This should also considered for facilities such as feed storage and office. Location of these facilities should facilitate the work, save energy and work.

Distance between farms

This is a very conflicting matter and a scientific solution has not been found for this yet. At present practice, the distance between ongrowing farms using same stream is minimum 500 m and 5 km between hatcheries. In cage culture the distance is 1000 m.

Area, type of soil

Area must be sufficient for foreseen capacity and possible future expansions and soil must be tested for construction of earth pond (where possible).

Shelter

The location of farm should be safe from floats and other natural effects and should not require additional protection facility.

Access

Comments for marine sites apply.

Services

Comments for marine sites apply.

Local infrastructure

Comments for marine sites apply.

Hazards

Comments for marine sites apply.

Potential sites for aquaculture in Turkey

There are several sites for marine and inland aquaculture in Turkey. However due to reasons listed before, full utilization of these sites have not been realized yet.

Fresh water

There are several streams especially in mountainous (coastal and inland) areas with very favourable water and temperature condition which is very convenient for trout farms and there are 43 dam lakes which have been allocated for cage culture of trout and carp. At the moment 1% of the surface area of the lakes are open to cage culture. However, no survey covering all Country has been conducted so far to determine the sites. Provincial offices of the Ministry are assessing the sites identified by the investors using criteria given in the previous section (Table 5).

Table 5. Inland fish producing water capacities (Source: The Ministry of Agriculture and Rural Affairs)

Fish producing sources	Numbers	Surface area (ha)	Length (km)
Natural lakes	200	906,118	-
Dam lakes	159	342,377	-
Ponds	750	15,500	
Rivers	33	-	177,714

Marine

A survey covering the whole Turkish coast was made in 1993 and 104 sites were identified as suitable for marine aquaculture (Table 6).

Table 6. Marine resources of Turkey (Source: The Ministry of Agriculture and rural Affairs)

The Seas	Coastal line length (km)	Surface area (ha)
Black Sea, Aegean Sea and Mediterranean	7,144	23,475.000
Sea of Marmara, Istanbul and Dardanelles	1,189	1,132.200
Total	8,333	24,607.200

Thirty-three sites were identified on the Black Sea coast. The Black Sea coast is very exposed to high winds and waves in the summer months and suffers from high summer surface temperatures. The main potential species were found to be salmon, sea trout and turbot if the problem of high surface temperatures could be resolved.

Three sites were identified in the Marmara Sea. The Marmara Sea does not suffer from such high summer water temperatures but has very high winds and strong currents. The main potential species were found to be salmon, sea trout, turbot, seabass, mullet and molluscs (mussels and oysters).

Thirty-seven suitable sites were identified in the Aegean. The Aegean is very suitable for the culture of seabass and seabream but the number of areas for aquaculture is severely restricted due to conflict with tourism, secondary housing, recreation areas and Specially Environmentally Protected Areas. Other potential species include eels, mullet, double banded bream and molluscs.

Twenty-four suitable sites were identified in the Mediterranean. The eastern Mediterranean has many areas suitable for the culture of fish and shrimp in lined ponds. Again many areas suitable for aquaculture production are in conflict with other activities.

Conclusions

It appears that most important issue of site selection is licensing procedure. More parties involved in the process, more problems occur. Competition between different sectors is the main factor affecting the development of farm sites in Turkey. Due to this reason many areas which are very convenient for aquaculture are not utilised. By developing co-ordination and understanding among parties, this problem could be solved. Another factor which could reduce the number of conflicts is technological development and their implementation, such as moving the cages to off shore and development of cheap environmentally friendly technologies of water treatments, chemicals, and medicines.