International Journal of Civil Engineering and Technology (IJCIET)
Volume 9, Issue 6, June 2018, pp. 478–488, Article ID: IJCIET_09_06_055
Available online at http://www.iaeme.com/ijciet/issues.asp?JType=IJCIET&VType=9&IType=6
ISSN Print: 0976-6308 and ISSN Online: 0976-6316

STUDY OF ANANTPUR COMMUNITY MICRO IRRIGATION PROJECT – DESIGN AND PREPARATION OF PROJECT PHILOSOPHY

Shekhar Kumbhar
M.Tech Student, Department of Civil Engineering,
Bharati Vidyapeeth Deemed University, College of Engineering Pune, Maharashtra, India

V.S. Sohoni
Professor, Department of Civil Engineering, Bharati Vidyapeeth Deemed University,
College of Engineering Pune, Maharashtra, India

P.T. Nimbalkar
Assistant Professor, Department of Civil Engineering,
Bharati Vidyapeeth Deemed University, College of Engineering Pune, Maharashtra, India

Ramdas Battalwar
Head Business Development, SBU Projects & Exports,
Netafim Irrigation India Pvt. Ltd., Pune, Maharashtra, India

Abhijeet Surve
Deputy Manager, Community Irrigation Division,
Netafim Irrigation India Pvt. Ltd., Pune, Maharashtra, India

ABSTRACT

World's population is growing at exponential rate and so the issue of water scarcity is having negatively increasing impact on global community, economics and sustainability. Among many other requirements agricultural irrigation water requirement is the largest and having major impact on world's different water consumption domains. With improvements and developments in saving of water in all other major sectors, considering necessity of improvements in overall efficiency of irrigation water system here is an attempt to give one of best solution in the form of community irrigation system. The community irrigation system has proven to be efficient and economical in overall as compared to conventional flood and canal irrigation system. Even though increase in overall project cost of community irrigation is increased by 18% as compared to canal irrigation, the increase in command area is by 2.4 times and the increase in yield can be about 22%.

Key words: Drip irrigation, community irrigation, Anantpur, drip.

Cite this Article: Shekhar Kumbhar, V.S. Sohoni, P.T. Nimbalkar, Ramdas Battalwar and Abhijeet Surve .Study of Anantpur Community Micro Irrigation Project – Design and Preparation of Project Philosophy, International Journal of Civil Engineering and Technology, 9(6), 2018, pp. 478–488.
http://www.iaeme.com/IJCIET/issues.asp?JType=IJCIET&VType=9&IType=6

1. INTRODUCTION

Water resource sector has made significant progress since independence. Still there is a lot of scope for meeting overgrowing and competing demands of water for agriculture, domestic and industrial requirements. Water is a very precious commodity, but its value is being appreciated only in the time of scarcity and its non availability. Now it's a need of time to adopt a comprehensive strategy to for conservation and optimum utilization of water resources in States/ Country to meet its demand on sustainable basis. Its need to improve the efficiency of irrigation system major, minor projects at all levels. Modernization, rehabilitation of existing and on-going projects, better operation and maintenance, more flexibility in regulation and scheduling of irrigation water are normally included in development strategy.

The real challenge for water scarcity issue is accessibility and productivity. This results in unequal water distribution among the farmers and leads to socio economic tensions. The development of new irrigation technologies like micro irrigation has resulted in dramatic increase productivity of water. Micro irrigation is widely acknowledged as one of the few solutions which address the challenges of not only the water scarcity but also of food security & depleting arable lands. But still the percentage of communities utilizing micro irrigation technologies is still low in developing and under developed regions.

The efforts to integrate water conveyance system with on farm water productivity has resulted in combining the piped distribution network with micro irrigation systems on field bypassing the inefficient canal irrigation system.

So, efficient distribution of available water with minimum losses can be is the prime factor in modernization of irrigation systems. Herein, an attempt has been made to deal with efficient distribution of water by using piped distribution network.

Adoption of community drip irrigation system have many advantages and can help in make judicious use of natural resources like water and energy, equitable distribution of irrigation water among all the beneficiaries, to avoid permanent land acquisition & to improve Water Use Efficiency (WUE) by 20% (as proposed by National Water Mission of the Ministry of Water Resources, Govt. of India).

One of the five goals of National Water Mission is to increase the water use efficiency in all sectors of water use by 20% by the year 2017 i.e. by the end of 12th Five Year Plan. The strategies have been identified in the Mission Document. It is more significant in irrigation sector, for about 80-85% of water consumption is in this sector. The prevailing water use efficiency of irrigation projects is in the range of 30 to 35% which could be enhanced to about 60% through systematic improvements. So it is the sector where there is immense scope for working upon improvement of irrigation efficiency & saving the huge volume of water for additional irrigation/other use.

Table 1 Comparison of Irrigation Efficiencies (Figures are in %)

Irrigation Efficiencies	Surface	Sprinkler	Drip
Conveyance	40-50	90-100	90-100
Application	60-70	70-80	90-95
Moisture Evaporation	30-40	30-40	20-25
Overall Efficiency	30-35	50-60	80-90

In overall comparison between the surface irrigation method with drip and sprinkler irrigation methods the drip irrigation can have an overall efficiency up to 80-90% whereas in canal irrigation system it would be only 30-35%.

The major thrust area at present has been to improve the efficiency of irrigation systems, which includes rehabilitation and modernization of existing and ongoing irrigation systems by better operation and maintenance and more flexibility in regulation and scheduling of irrigation water.

The piped distribution, can be adopted in situations like,

- Extensive command area with limited water availability
- Uneven terrains and steep topography
- Heavy seepage losses and trouble with burrowing animals
- Adoption of modern techniques in required

For improvement of irrigation water management bellow the outlet a well designed and carefully laid distribution network of field channels is very important. In India, open field channels are generally used in canal command area and both lined and unlined channels are used to deliver water to farmer's field. In this type of channels and in open canals, most of the water is lost due evaporation, seepage losses and malpractices. In piped distribution these parameters can be controlled and minimized to reduce adverse effect on irrigation efficiency.

Use of micro irrigation system with piped distribution network can increase the irrigation efficiencies, water savings as well as yield of the crops.

Drip irrigation systems for large scale community irrigation project is need of time and is also in line with policy of National Water Mission, Ministry of Water Resources, Govt. of India which promotes the integrated management of water resources and increase in water use efficiency by 20 %.

2. COMMUNITY DRIP IRRIGATION (CDI)

Conventionally water is transported through the network of canals from the source like reservoirs etc to the field. The canals are may be lined or unlined canals. The loss of water in lined canals is less as compared to the unlined canals, but still the transportation through the canal network is not an efficient way of transportation. There are also few disadvantages of this system like, requirement of lands, water losses by seepage as well as evaporative losses, erosion and siltation of canals, frequent over-toppings, weed/plantation problems, unsafe from safety point of view, water losses by way of pilferage, canal network execution/installation time, the water flow regime, the route direction of flow, less irrigation efficiency, Economic return on per unit of water, operation and maintenance.

Presently most critical input for Indian agriculture is water. Available water supply should be utilized to the best possible advantage. Recent experiments and demonstrations shows that, irrigation water use efficiency can be increased up to 200% in certain conditions. Water management involves the knowledge of soil-plant- water relationships.

2.1. Advantages of Community Drip Irrigation

- Little loss of farm land compared to open channel network.
- Virtually no water loss
- Prevention of water logging and weed growth
- Low maintenance cost
- Better control
- Less seepage loss
- No evaporation loss
- Flexible to operate
- No soil erosion
- Installation is easy
- Long Life
- Disease and pest problems are minimum
- Economy in laying as no culverts or other structures are required

2.2. Disadvantages of Community Drip Irrigation

- Greater initial investment
- Corrosion hazards
- Requires high skills in design and installation
- Higher filtration costs for water which contains large amount of sediments

3. STUDY AREA

3.1. Jayapuram Drip Irrigation Project

This proposed project is located in Kudairmandal, district Anantpur, Andhra Pradesh. In this project water will be lifted from HNSS canal, this is a lift cum drip irrigation project. The lifted water will be then conveyed further through network of pipes and delivered directly to the root zone of plants using drip irrigation network. This is to ensure about the water conveyance and on farm water efficiency. This project is aimed at to address the water scarcity problems, erratic and scanty rainfall issues, increase in crop yield and productions.

Proposed solution for water scarcity issues is to implement the community drip irrigation system, which will help to increase the irrigated area with available amount of water as compared to canal irrigation system. The available water quantity is of 13.64 MCM (Million Cubic Meters) able to irrigate only 2000 ha, whereas under drip irrigation system the same quantity of water to irrigate area of 4873 Ha spread over in 04 villages. This is due to difference between overall efficiency under drip irrigation and canal irrigation system. The four villages covered under this project are, Korrakodu, Jayapuram, Cholasamudram and Muddalpuram.

The source of water is from HNSS (Handri Niva Sujala Sravanthi) canal, linked to Krishna River and location of project is near the PABR reservoir. The agriculture is this area is highly affected by poor water availability. Out of 24900 Hectares (Ha) of cultivated area only 11.6 % is irrigated, which is bellow district average of 13% and state average of 13.5 %. Entire irrigation is dependent on rainfall, which is the major reason of under development of the region.

4. TECHNICAL CALCULATIONS AND PROJECT FEASIBILITY

In this project water will be lifted from HNSS canal to irrigate irrigation command area via. Network of distribution pipes and drip irrigation system installed at the farm.

It is proposed to divert water from HNSS canal to operational reservoir by construction of suitable intake canal. From operational reservoir pumping system will lift the water to irrigate entire proposed command area.

The pumping station will distribute the water to zones with an average cultivable command area of 162.4 Ha. Primarily considering 10% of area uncultivable out of gross command area (GCA) due to stones and higher elevations.

Each zone will be further divided into 05 sub-zones with an average area of 32.5 Ha. The size of zones and sub-zones will be decided by due consideration of proposed filtration system and PVC pipe line sizes.

Considering high undulations over the project area spread and for optimum utilization of power, the area will be divided into three pressure zones. The proposed pumping station 1 & 2 will be at elevation of 434 m. Area up to 460 m contour will be operated on low head pump station directly from reservoir. While area between 460 & 470 mtr contour is proposed to be operated with low head pumps at operational reservoir proposed at 478 m contour, and area above 470 m is planned on high head pumps from operational reservoir.

Considering land topography, water quality, better distribution efficiency, equitable distribution, inline pressure compensation (PC) emitters are proposed. Also considering agronomic factors, soil characteristics, cost optimization issues emitter discharge of 1.6 LPH (Litres per Hour) at 0.4 meter c/c (centre to centre) spacing is selected.

Also considering crop suitability of most of crops, lateral spacing is decided as 1.22 meters (4 feet). The considerations for design of irrigation system are as given bellow.

Table 2 Basic Data for design of irrigation system

Area	Total	Zone	Sub-zone
Area (Ha)	4,873.37	162.4	32.5
Crop	Mixed	Mixed	Mixed
Emitter	NPC Inline	NPC Inline	NPC Inline
Emitter discharge (lph)	1.6	1.6	1.6
Emitter spacing (m)	0.4	0.4	0.4
Lateral spacing (m)	1.2	1.2	1.2
Application rate (mm/hr)	3.33	3.33	3.33
Peak water requirement mm/day	3.7	3.7	3.7
Shift duration (Hr)	1.11	1.11	1.11
Available operational hrs/day	16	16	16
No of shifts / day	14	14	14
Actual operating hrs/day	15.54	15.54	15.54

Average shift area (Ha)	348.1	11.6	2.32
Average shift flow (m3/hr)	11603.26	386.78	77.36
Total no of zones	30	1	-
Total no of sub-zones	150	5	1
Total no of solenoid valves	2,100.00	70	14
Max. Discharge variation (%)	0	0	0
Water source	Reservoir	Reservoir	Reservoir

Table 3 System design parameters decided for drip irrigation system design

Subject	Data / Solution
Required Flow Variation in a Hissa (Farmer Block)	15% - Non Pressure Compensated Drippers
Hissa (Farmer Block) Size	According to Survey details maps and assumption that the minimum land holding size of farmer is 1 Ha
Hissa (Farmer Block) layout	According to Survey details maps and assumption that the minimum land holding size of farmer is 1 Ha
Row direction	According to the Designer decision, but within one Hissa same direction for entire Hissa (also if there is an obstacle in the middle). Google earth images can also be referred for more accuracy.
Max. Flow velocity	Feeder line: 1.8 m/s
	Mainline: 1.8 m/s
	Sub-mains: 2.0 m/s
	Irrigation Manifold: 2.5m/s
Pipes classes & types HDPE/ PVC India Standard (IS 4985-2000)	Feeder line: According to the Pressure, Class 3 (6.0 kg/cm2) and Class 4 (8.0 kg/cm2)
	Mainlines: According to the Pressure, Class 3 (6.0 kg/cm2) and Class 4 (8.0 kg/cm2)
	Sub-mains: Class 2 (4.0 kg/cm2)
	Irrigation Manifold: Class 2 (4.0 kg/cm2)
	Pressures at static condition + 10 % safety factor
Pipes sizes for design	Feeder Line - as per design and 1.8 m/s max. Velocity
	Mainline - as per design and 1.8 m/s max. Velocity
	Sub-main - as per design but not less than 63 MM
	Irrigation Manifold - as per design but not less than 40 MM
Working pressure range in Hissa (Farmer Block) (to achieve 1.6 l/hr dripper flow)	Pmin. = 10m & Pmax. = 18 m. at critical plots valve inlet, Pmax. = 21 m. at all other plots valve inlet
	Same D/S pressure for all Control Hyd. valves is recommended
Shifts pattern	Concentrated per Sub-zone - around 6% of the Sub-Zone in 1 shift, one 4" valve
Feeder lines, Main lines and Sub-mains location	According to the Designer decision, can cross the Hissas in any place to be the shorter and the economic results
Irrigation Manifold location	First priority - on Hissa boundary.
	Second priority - inside the Hissa feeding one or 2 sides.
Control Hyd. Valves (Field/Block) location	On blocks boundary.
	2 valves at same location / cluster, controlling 2 plots. Only in rare conditions cluster may have 1, 3 or 4 valves!
Hissa Manual Valve + Venturi / Fertigation Tank location	On Hissa's boundary. Either at centre of plot or at corner depending on topography. If 2 Hissa's use same valve and venturi - place them in one location between the 2 Hissa's
Length of Laterals	According to DESIGN, maximum possible length which enable head loss allocation (preferably 125m for selected product).

5. COMPONENTS OF PIPED DISTRIBUTION NETWORK

Component	Description
Existing Main Canal HNSS CANAL	The Main Canal i.e. HNSS Canal which is already constructed and Head regulators are constructed at various points.
Main Collection Sump	Main Collection sump from Head Regulator at Main Canal for collecting water with 30 Minutes retention capacity at the inlet locations by gravity through MS Pipe network
Planning of Zones and Sub Zone	The blocks are further divided in zones. Zones shall be decided in such a way that it falls within one village, which will be helpful in formation of WUCS. The Stream, Naalas and village boundaries need to consider while deciding on Zones. Wherever the area of block is in the range of 100.0 to 200.0 Ha a single zone is proposed. There will be sump cum pump house with 30 min. retention capacity at inlet. Wherever the area exceeds 200.0 Ha under the blocks, it is divided in to required no of zones of area 100.0 Ha each. Further the Zones are then divided in Sub Zones of area 20 - 50 Ha. Divisions of zones and subzones would depend on total project area, available water & total irrigation time available.
Gravity Feeder	Gravity feeders from main collection sump to individual zone sump cum pump house of respective zones for feeding required water
	1. Alignment of feeder pipes are planned in such a way that the land acquisition is bare minimum cost
	2. It should be avoiding villages, tanks, burial grounds, temples , mosques, churches, etc., and
	3. Generally planned along the existing Pathways as far as possible
Electrical Network and Transformer	It is proposed to provide Double circuit line from nearest electrical substation, to outlet point.
Sump cum Pump House	Sump cum pump house is designed to accommodate suitable No of Submersible pumps with 1 Standby pump. Supply, Installation, testing and commissioning of pumping machinery and pump house electrical works.
Control Room	Construction of Pump House cum Control Room for Pumping area and Only Control Room for Gravity Area
	1. The Control room should be adjacent to Road or should be accessible
Pumping Machinery	Supply, Installation, testing and commissioning of pumping machinery and pump house electrical works.
Primary Filtration system at Pumping station	Primary Filtration System suitable for required flow of 130 Micron Self Cleaning Automatic Filter with Online Back Flush at Pumping Station is to remove the Dirt Load and Suspended Solids from the water which will enhance the Irrigation system Life and increase the Life of project.
SCADA & Radio Net Automation System	SCADA system at pumping station consists of control centre to Control pumping station, Distribution Management System, Solenoid Valve or Outlet Distribution Control Unit Management System with Radio Net Automation System
Water Flow Meter	Total Flow will be monitored at Zone Level with ultrasonic water meter
HDPE Pipe Network	Supply, jointing, laying, testing and commissioning of HDPE pipe for conveying water in the Zones to individual sub zone
	HDPE Pipe Network are generally planned along the field bunds
Secondary Filtration system at Sub Zone	Secondary Filtration System suitable for required flow of 130 Micron Self Cleaning Automatic Filter with Online Back Flush at Sub Zone station is to remove the Dirt Load and Suspended Solids from the water which will enhance the Irrigation system Life and increase the Life of project.
Water Meter	Flow will be monitored at Sub Zone Level with water meter
Main and Sub Mains	Supply, jointing, laying, testing and commissioning of PVC pipe of required pipe class and required pressure rating for conveying water from

	sub zones to the field outlets.
	Main and Sub Mains Pipe Network should be planned along the field bunds
Automatic Valve	Supply and Installation of Solenoid valves for each 14 shift at 20-50 Ha Sub Zone level in conjunction with irrigation controller. (Nos of shift depend on available irrigation time, total project area and discharge available.)
Farmer Control Valve and Flush Valve	Supply of control valve and Flush valve to individual farmer
Fertilizer Tank/Venturi	Supply of fertilizer tank/venturi assembly to individual farmer
Drip Irrigation Manifold	Supply of Pressure compensated Drip Irrigation manifold and accessories for the uniform distribution of irrigation water
Operation and Maintenance for 5 years	Spares and Tools should be provided by the Agency for the required items generally as per schedules and Operation and Maintenance for 5 years
Water Users Cooperative Societies	Formation of water user Co operative society
Training and Capacity Building	Training and Capacity Building of Farmer's and Departmental Officials
Post Harvesting Linkage	Support to Farmer for Post Harvesting linkage with required tie-ups with Agro Processing Industries

6. COST ANALYSIS

6.1. Community Drip Irrigation Cost Per Hectare

In community drip irrigation system, there are five major components as given bellow.

- Engineering and design
- Electro-mechanical
- Civil Works
- Drip Irrigation System (Including automation system, in-field control system, head control units, fertigation system, mainlines and sub-main lines)
- Operation and maintenance of system (Including Agronomical support and agriculture extension activities)

Table 4 Project Cost breakup; Source: SSR WRD (Schedule of Standard Rates, Water Resource Department)

	Project Area, Ha	**4873.4**		
Sr. No.	**Description**	**Rs. (Crores)**	**Cost Per Ha, Rs.**	**% of Total Cost**
A	Engineering and design services	2.5	5130	1
B	Electro-mechanical works	10.7	21913	5
C	Civil works	52.9	108573	26
D	Drip Irrigation System	125.2	256877	62
E	Services	1.9	4000	1
F	Taxes, LA, Establishment and deposits	9.5	19514	5
	Total Project Cost	**203**	**416008**	**100**

6.2. Canal irrigation cost per hectare

Cost of canal irrigation per hectare based on 2000 hectare is as given bellow.

Table 5 Canal Cost Per Hectare

Area, Ha	**2000**		**4873**	
Particulars	**Rs., Crores**	**Cost Per Ha, Rs.**	**Rs., Crores**	**Cost Per Ha, Rs.**
Lift Infrastructure				
Civil Cost	4.8	23944	11.7	23944
Power Cost	0.8	3977	1.9	3977
Land Acquisition Cost	0.4	2000	1.0	2000
Laying of Canal				
Civil Cost	30.2	151060	73.6	151060
Land Acquisition Cost	40	200000	97.46	200000
Irrigation Cost per hectare	76.2	380981	185.7	380981

Table 6 Benefit Cost Ratio (Drip Vs Canal+Rainfed)

KPIs	**Ha**	**Rain-fed+ Canal**	**Drip**	**%**	**Comments**	
					CDI vs Canal + Rain-fed	
Rain-fed area	Ha	2,873	-	-	+	No dependency on rain
Irrigated area	Ha	2,000	4,873	143%	+	Irrigated area increases by 2.4 times
Total area	Ha	4,873	4,873	-	+	
Water	MCM	33.17	13.64	41%	+	41% saving in water
Yield / ha	Kg/ha	1,02,625	1,12,750	10%	+	10% increase in yield
Output	Tons	36,275	91,612	153%	+	2.5 times increase in output
Gross income	Rs. Cr	6,227	14,315	130%	+	2.3 times increase in gross income
Net income	Rs. Cr	4,353	12,037	177%	+	2.8 times increase in net income
Cost per ha	Rs/ha	3,80,981	4,50,684	18%	-	18% increase in per hectare cost

Table 7 Financial key performance index (Drip Vs Canal + Rainfed)

Financial KPI (Key Performance Index)	**Without Discounting**	**With Discounting @ 12%, 10 years**
Benefit Cost ratio	5.2 times	3.1 times
Payback period	3.1 years	3.7 years
Net Present Value	NA	Rs 226 crores
IRR (Internal Rate of Return)	Na	49.70%

Table 8 Benefit Cost Ratio (Drip Vs Canal)

KPIs	Ha	Canal	Drip	%	Comments: CDI vs Canal	
Irrigated area	Ha	2,000	4,873	144%	+	Irrigated area increases by 2.4 times
Water	MCM	13.64	13.64	-	+	2 times + irrigated area with same quantity of water
Yield / ha	Kg/ha	92,625	1,12,750	22%	+	22% increase in yield
Output	Tons	31,175	91,612	194%	+	2.9 times increase in output
Gross income	Rs. Cr	4,886	14,351	194%	+	2.9 times increase in gross income
Net income	Rs. Cr	3,805	12,037	216%	+	3.2 times increase in net income
Cost per ha	Rs/ha	3,80,981	4,50,684	18%	-	18% increase in per hectare cost

Table 9 Financial key performance index (Drip Vs Canal)

Financial KPIs	Without Discounting	With Discounting @ 12%, 10 years
Benefit Cost ratio	5.5 times	3.3 times
Payback period	2.9 years	2.9 years
Net Present Value	Na	Rs 250 crores
IRR	Na	42.70%

7. CONCLUSIONS

Project area is highly dependent on rainfall; around 88% is rain-fed area. Rain fall in the project area is highly erratic about on an average 31 days of rainfall. Water allocation in the dam or canal is significantly less which can irrigate only 42% of the area with traditional systems. Various costs like land acquisition, canal construction and social issues has increased the cost of canal irrigation network. Whereas the community drip irrigation can increase the area about 2.4 times with same quantity of water presently allocated. Impact of drip irrigation also increases the yield by around 22% and the total output around 193 %, causing to increase in net income of farmers by about 3.2 times. Even though the project cost of drip irrigation is increased by 18 % over canal irrigation, overall benefits in the form of net income to farmer can be increased by 3.2 times or 216%.

ACKONWLEDGEMENT

The authors express their deepest gratitude to Dr. A. R. Bhalerao (Principal), Bharati Vidyapeeth University College of Engineering, Pune, for their support and encouragement. The authors are also thankful to Netafim Irrigation India Pvt. Ltd. for their valuable cooperation and timely guidance during the course of project studies.

REFERENCES

[1] A. Narayanamoorthy, Potential For Drip And Sprinkler Irrigation In India,2006.

[2] Anantapur Extreme Weather Events in the month of May Table Period: 2007–2016, India Meteorological Department, 2017.

[3] Central Public Health and Environmental Engineering Organization (CPHEEO), Manual on Water Supply and Treatment, New Delhi, 1999.

[4] Guidelines for Planning and Design of Piped Irrigation Network, July 2017, Ministry of Water Resources, River Development & Ganga Rejuvenation, Central Water Commission, Government of India.

[5] Guidelines for Planning and Design of Piped Irrigation Network, October 2016, Ministry of Water Resources, Designs (N & W) Unit, Central Water Commission, Government of India.

[6] Water 2030 Global Water Supply and Demand Model, Agriculture production based on IFPRI impact-water base case.

[7] Jyotsna Ramchandra Kore, P.T.Nimbalkar and PriyaHi rave Crop Water Requirements and Irrigation Scheduling of Some Selected Crops Using Cropwat 8.0 : A Case Study of Khadakwasla Dam Irrigation Project. International Journal of Civil Engineering and Technology , 8(5), 2017, pp. 342–349