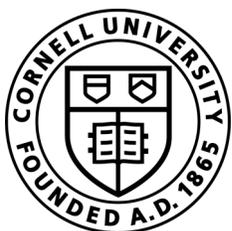


# DACUM Research Chart for Indoor Farm Operations Manager

Produced for



Cornell  
**CALS**

College of Agriculture  
and Life Sciences



CORNELL

**Small Farms**

PROGRAM

Produced by



**THE OHIO STATE UNIVERSITY**

CENTER ON EDUCATION AND  
TRAINING FOR EMPLOYMENT

**Prime Produce Apprentice Cooperative**

**New York, New York**

**May 7 & 8, 2019**

**[dacum.osu.edu](http://dacum.osu.edu)**

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# DACUM Research Chart for Vertical Farm Operations

DUTIES	TASKS			
<b>A. Manage Crop Production</b>	A.1 Manage crop fertigation (e.g., mixing nutrients, monitoring pH, monitoring water temp)	A.2 Perform visual crop assessment	A.3 Implement IPM plan	A.4 Implement crop-specific SOPs (e.g., propagation, transplanting, harvesting)
	A.10 Create crop production plans	A.11 Revise crop production plans	A.12 Coordinate with sales on product supply	A.13 Manage environmental controls (e.g., temp, CO2, RH)
<b>B. Manage Farm Labor</b>	B.1 Determine labor needs	B.2 Create employee schedules	B.3 Inform team of daily plans	B.4 Delegate planned/routine tasks
	B.10 Provide employee feedback and coaching	B.11 Participate in employee onboarding activities (e.g., hiring, interviewing)	B.12 Conduct company-specific employee training	B.13 Manage supplemental labor (e.g., interns, contractors)
<b>C. Implement Product Safety Plan</b>	C.1 Oversee operations hazard analysis (e.g., HACCP, prerequisite, risk assessment)	C.2 Inspect product safety control points	C.3 Implement employee product safety training program	C.4 Manage product safety audits (e.g., routine, annual)
	C.10 Implement product safety water quality management plan	C.11 Support recall plan (e.g., traceability, product, consumables)	C.12 Support approved supplier program	C.13 Coordinate product safety sampling and testing (e.g., seeds, surfaces)
<b>D. Manage Post-Harvest Processing</b>	D.1 Confirm customer order details (e.g., quantity, SKU, destination)	D.2 Gather production data (e.g., usable yield, waste)	D.3 Oversee post-harvest QC processes (e.g., metal detection, weights and measures, sorting)	D.4 Oversee post-harvest packaging and labeling (e.g., traceability, lot numbers)
	D.10 Manage post-harvest agricultural waste streams			
<b>E. Oversee Distribution Logistics</b>	E.1 Coordinate inventory with sales	E.2 Organize orders according to sales channel	E.3 Collect delivery documentation (e.g., logs, invoices, purchase orders)	E.4 Oversee delivery vehicle loading
<b>F. Evaluate Farm Data and Metrics</b>	F.1 Develop data strategy	F.2 Implement data collection procedure (e.g., software, tooling, process)	F.3 Support database management (e.g., clean, verify, structure)	F.4 Analyze production data (e.g., yield, loss)

A.5 Oversee preventative maintenance (e.g., sensor calibration, clean filters, sanitization)	A.6 Manage production logs	A.7 Manage incident logs	A.8 Diagnose crop disorders (e.g., nutrient deficiencies, physiological disorders)	A.9 Conduct sampling activities (e.g., tissue, water, substrate)
A.14 Program automated tasks (e.g., watering, lighting)	A.15 Monitor system functionality	A.16 Conduct root cause analysis		
B.5 Delegate non-routine tasks	B.6 Supervise employee performance	B.7 Perform end-of-day assessment	B.8 Manage team goals and KPIs	B.9 Organize team meetings
B.14 Resolve employee conflicts	B.15 Participate in disciplinary process			
C.5 Implement food safety SOPs (e.g., hygiene, sanitation, PPE)	C.6 Verify product safety compliance (e.g., documentation, logs, mediate)	C.7 Verify facility safety compliance (e.g., logs, mediate, security)	C.8 Review product safety plan (e.g., annually, continuously)	C.9 Implement pest management program (e.g., rats, roaches)
D.5 Oversee post-harvest cleaning and sanitation (e.g., equipment, tools)	D.6 Prepare product for hand-off to logistics (e.g., box, pallet, bin)	D.7 Update ERP with production data	D.8 Manage post-harvest production pace	D.9 Monitor employee GMP/SOP compliance (e.g., safe-handling, contamination)
E.5 Manage condition of delivery equipment (e.g., vehicles, lift gates)	E.6 Manage delivery personnel	E.7 Resolve delivery issues	E.8 Verify product delivery (e.g., timely, QC, temp)	
F.5 Analyze growth parameter data (e.g., light, nutrients, climate)	F.6 Analyze labor data	F.7 Track production KPIs	F.8 Compare data to benchmarks (e.g., internal, external, academic)	F.9 Address areas for improvement (e.g., production, nutrients, environment)

# DACUM Research Chart for Vertical Farm Operations I

## DUTIES

## TASKS

DUTIES	TASKS			
	F.10 Generate production forecasts	F.11 Evaluate incident reports (e.g., food safety, worker performance, system failure)		
<b>G. Manage Site-Level Profit and Loss</b>	G.1 Determine capital costs	G.2 Determine operating expenses	G.3 Advise sales on product pricing	G.4 Develop operating budgets
<b>H. Implement Continuous Improvement Plans</b>	H.1 Conduct feasibility studies	H.2 Identify improvement targets (e.g., variety, yield, hardware)	H.3 Research existing solutions	H.4 Design experiments to explore innovations
	H.10 Monitor industry trends	H.11 Obtain strategic certifications	H.12 Address employee feedback (e.g., work-life balance, PTO, responsibilities)	H.13 Support strategic partnership development
	H.19 Create new operational processes			
<b>I. Oversee Facility Maintenance</b>	I.1 Develop maintenance checklists	I.2 Perform equipment inspections	I.3 Perform facility inspections	I.4 Identify maintenance/repair needs
	I.10 Manage spare parts inventory	I.11 Determine equipment needs (e.g., repair, replace, upgrade)	I.12 Maintain facility security systems	I.13 Verify sensor alarm coverage (e.g., on-call, response plan)
<b>J. Manage Production Inventory</b>	J.1 Manage inventory lists	J.2 Track consumable inventory	J.3 Forecast inventory consumption	J.4 Order production inventory
	J.10 Negotiate production inventory supplier pricing (e.g., research, compare, verify)	J.11 Maintain production inventory documentation (e.g., receipts, purchase orders)		
<b>K. Maintain Relationships with External Stakeholders</b>	K.1 Manage visitor permissions (e.g., tours, PPE)	K.2 Support community outreach programs (e.g., schools, volunteers)	K.3 Support business relations (e.g., customers, investors, partners)	K.4 Support marketing efforts (e.g., social media, outreach)
	K.10 Manage supplier relationships	K.11 Oversee hired contractors (e.g., food safety, sanitation)		

G.5 Monitor production targets	G.6 Perform P&L reviews (e.g., quarterly, monthly, overlaying KPIs)	G.7 Analyze P&L variances (e.g., highs, lows)		
H.5 Supervise research experiments	H.6 Summarize research findings	H.7 Conduct workflow analysis (e.g., inefficiencies, ergonomics)	H.8 Implement target improvements (e.g., hardware systems, workflow, production)	H.9 Oversee product development (e.g., new SKUs, labels, customer demands)
H.14 Identify infrastructure improvements (e.g., facilities, automation, system)	H.15 Determine professional development opportunities (e.g., internal growth, external education)	H.16 Evaluate internal management strategies (e.g., feedback loops, meetings, individual check-ins)	H.17 Implement Lean techniques	H.18 Create new KPIs
I.5 Coordinate equipment/facilities repairs (e.g., in-house, contracted)	I.6 Verify maintenance/repair completion (e.g., code, quality, waste removal)	I.7 Develop preventive maintenance cleaning schedule	I.8 Perform scheduled preventive maintenance	I.9 Maintain facility/equipment maintenance logs
I.14 Oversee facility managers (e.g., safety, schedules)				
J.5 Manage inventory storage space (e.g., allocate, organize)	J.6 Implement production inventory traceability	J.7 Conduct production inventory QA check	J.8 Manage chemical storage (e.g., safety, compliance, handling)	J.9 Maintain production inventory cold storage
K.5 Participate in industry events (e.g., panels, trade shows, networking events)	K.6 Prepare external presentations and reports	K.7 Engage in consulting exchange (e.g., academic, private, co-op extension)	K.8 Support policy development (e.g., regulations, best practices)	K.9 Negotiate vendor contracts

# DACUM Research Chart for Vertical Farm Operations

DUTIES	TASKS			
<b>L. Maintain Regulatory Compliance</b>	L.1 Identify regulatory requirements (e.g., licenses, certifications)	L.2 Maintain manufacturing certifications (e.g., weights and measures, GMPs, ISOs)	L.3 Maintain production certifications (e.g., kosher, organic, non-GMO)	L.4 Maintain personnel certifications (e.g., pesticide applicator, food safety, equipment)
<b>M. Perform Administrative Tasks</b>	M.1 Prepare operations reports	M.2 Create operations work plans (e.g., timelines, schedules)	M.3 Manage internal/external communications (e.g., email, phone,	M.4 Maintain departmental files (e.g., handbook, logs)

## Future Trends and Concerns

### Automation and Data

#### ◆ Data-driven farming

- Concern: Long-term job stability for lower-skilled farm workers is threatened by automation
- Trend: New software brings a need for more computer literacy and programming skills
- Trend: Companies are building software for ag and creating positions related to software
- Trend: Blockchain (“get ready!”)
- Trend: Traceability

### Climate and Environment

#### ◆ Climate change

- Trend: Volatility of growing outdoors is good for VF as industry, but also terrifying
  - ◆ Need for resilience

#### ◆ Nutrient sourcing and run-off

- Concern: Sustainability of inputs and outputs—how circular is VF, or can it be?

### Culture

#### ◆ Public perception about VF/CEA is changing

- Concern: Some consumers may see food grown indoors as inferior or unnatural
  - ◆ But others may increasingly prefer it as higher-quality and/or cleaner
- Concern: General sense of VF as fad
  - ◆ System may not meet the needs of present and future consumers, or of environmental sustainability
  - ◆ Tied in with other tech fads, such as automation and blockchain
  - ◆ Can VF scale? Will it scale up over 10–20 years?
  - ◆ Concern over promises made versus promises kept
  - ◆ Concern over solving real problems

#### ◆ How does VF/CEA fit into the larger New Food movement?

- Concern: Ambiguity re organic certification
- Concern: Food security—does VF address this?
- Concern: Food justice—does VF address this?
  - ◆ Criticism regarding cost and energy consumption relative to food justice advocates
  - ◆ Criticisms regarding diversity of growers as well as crops produced commercially by large VFs to date
    - Eating diverse foods is more important than eating locally
- Trend: Local foods
  - ◆ Boom, bigger than organic right now—a positive for VF (see the National Restaurant Association report on local)
  - ◆ Question: what *does* “local” mean? What about very efficient shipping? (i.e., shipping is not the problem, from a food-mile/CO2 perspective)

#### ◆ Lack of education among consumers regarding hydroponics and aquaponics

### Energy and systems design

#### ◆ Energy use

- Concern: The math on KWHs/biomass Kg doesn’t work at present

#### ◆ Hardware obsolescence

- Concern: Schools should rent lights, e.g.

#### ◆ Questions around VF systems lead to the companies being unstable or perceived as such

L.5 Maintain health and safety compliance (e.g., breaks, emergency response plan, first aid)	L.6 Maintain government compliance (e.g., permits, labor regulations)	L.7 Conduct employee regulatory training		
M.5 Prepare performance reviews	M.6 Prepare purchase requisitions	M.7 Manage employee time sheets	M.8 Prepare expense reports	

- Concern: Few standards for the industry
  - ◆ This is taxing on farm managers, farmhands, engineers
- Concern: Standards are perceived to threaten startups' IP—leads to protectionism
- ◆ **Flexibility of systems**
  - Trend: You can put them in more places—including a parking lot
    - ◆ You can produce year-round
    - ◆ Year-round jobs
  - Concern: Scalability of aquaponics?
  - Concern: Lack of standardized system design for specific crops
- ◆ **Distributed farming**
  - Trend: Also growing! “Comeback of the small farm”
  - Trend: Increased interest in home growing, esp. using hydroponics: This is tied to an increased interest in self-sufficiency
- ◆ **Genetic engineering**
  - Trend: Will affect all aspects of agriculture including VF/CEA systems and business models
- Finance and Investment**
- ◆ **Industry success**
  - Concern: The amount of money in the sector has put “inappropriate” pressure on VF operations, inflating salaries of growers
  - Concern: “There’s no way this is one position” but three or four jobs
- ◆ **Capital costs**
  - Concern: Barrier to entry is very high
  - Concern: Loss of investment support: Fewer new farms? What happens when VF is no longer a darling of VCs?
- Labor**
- ◆ **Recruitment**
  - Concern: Need to manage job expectations: Recruits expect high salaries, high tech, and romantic farm work
  - Concern: Lack of experienced growers
    - ◆ Trying to find more growers, and they are not as well-rounded as they think they are. They know a little about everything, but can’t help with improving systems
    - ◆ School plus on-the-ground experience is necessary
    - ◆ At the best CEA schools, the lights are two years old; the lights have changed four times in that period
    - ◆ Lack of good school programs, lack of apprenticeships—but lots of interest: Need to find a way to retain apprentices from universities
- ◆ **Decreasing rural population**
- ◆ **Changes in farm labor**
  - Trend: Probably going to be paid better
- ◆ **Diversity of workforce**
  - Concern: Need for more inclusive hiring practices for leaders and growers
- Distribution and Markets**
- ◆ **Evolving distribution system**
  - Concern: As distribution becomes more efficient (with automated vehicles), “local” will become devalued as a quality
    - ◆ Also, consolidation of major grocery chains: they have white labels, could just grow their own food, cut out farmers entirely

## **Knowledge**

Agricultural experience/practices  
Basic biology  
Climate science/earth science  
Experimental design (“basic scientific method”)  
Fluid dynamics  
Food safety  
Horticultural techniques  
HVAC fundamentals/psychrometrics  
Irrigation techniques/fundamentals  
Lighting  
Manufacturing equipment  
Market awareness  
Mycology  
Organic chemistry  
Plant disease  
Plant nutrition  
Plant pests  
Plant science  
Plant/crop maintenance  
Planting techniques  
Principles of energy (thermodynamics, electricity)  
Regulatory organizations  
Water chemistry

## **Skills**

Analysis  
Basic construction ability  
Basic electrical engineering  
Chemical handling techniques  
Communication (written, verbal, non-verbal)  
Compressed gas handling techniques  
Computer science  
Data analysis  
Data collection  
Evaluation  
Identification  
IPM  
Management  
Manual dexterity  
Observation  
Optimization techniques/processes (LEAN, Six Sigma, etc.)  
Organizational skills  
Pesticide handling techniques  
Plumbing skills  
Problem-solving  
Sterile technique, autoclave  
Strategic planning  
Technical writing  
Technology  
Time management  
Troubleshooting

## **Future Trends and Concerns, Cont'd**

- Trend: Counterpoint: the problem with long supply chains isn't cost but *time*: nutrients and flavor decrease as miles increase; this holds regardless of efficiencies in shipping

### ◆ **Increased shelf life of CEA products compared to field**

- Trend: VF can get better at this, and it's a major advantage
  - ◆ Calcium chloride study—found to increase shelf life

### ◆ **Market demand**

- Trend: The field is growing!

### ◆ **Berries and cannabis represent new markets for VF/CEA**

#### **Political Economy**

### ◆ **More of the same”—capitalism**

- Concern: Larger farms fit right into the industrial food system, marginalizing people of color. There is a low amount of participation from minority communities
  - ◆ Ag and an industry is exploitative: There is no reason that VC-backed VFs won't fit into this strong trend

### ◆ **Circular economy**

- Trend: The transition from linear to circular production favors (some) VFs

#### **Regulation**

### ◆ **Increasing food safety regulations**

- Concern: Might be good for VFs, but what happens when VFs are lumped in with conventional farms where most foodborne epidemics have originated, to date?

### ◆ **Regulations, esp. re organic**

- Trend: Increase in regulations specific to VF and hydroponics? “It's happening”
  - ◆ Regulations around organics
- Concern: Community against hydroponics being USDA certified organic: “toxic,” “vitriol”
  - ◆ They're losing market share to CEA
  - ◆ They also want to protect soil
  - ◆ So eventually hydroponics may not be organic at all
  - ◆ Hydroponics will have to be regulated

### ◆ **Biodiversity**

- Trend: Indoor systems can grow more types of crops, bring more crops into the food system

### **Interacting with food production**

- Trend: Creates transparency, engagement

## **Behaviors**

Adaptable  
Assertive  
Common sense  
Confident  
Critical thinker  
Dependable  
Detail-oriented  
Determined  
Embodies company mission  
Energetic  
Ethical  
Even-tempered  
Flexible  
Goal-oriented  
Goes above and beyond  
Good listener  
Good memory  
Health-conscious  
Honest  
Humble  
Integrity  
Instestinal fortitude (not easily grossed out,  
not disgusted easily)  
Mechanically inclined  
Mission-oriented  
Multitasker  
Observant  
Overachiever  
Passionate  
Patient  
People-oriented  
Problem solver  
Respectful  
Safety-oriented  
Sense of humor  
Smart  
Stamina, physically fit  
Team player  
Timely, punctual

## **Tools, Equipment, Supplies and Materials**

Anemometer  
Blade sharpener  
Business analytic tools (ERP, Business Intelligence, Tableau)  
Business ops software  
Colorimeter  
Computer  
CoolBot (temperature controller)  
Dosatron  
EC meter  
Enterprise resource planning tools (Quickbooks, SAP, etc.)  
Filters – HVAC, irrigation, skim  
Fire extinguisher  
First aid kit  
Germination chambers  
Google Suite (Sheets, Calendar, Docs)  
Grow-operations software (Prolink, Agroteck, Argus)  
Hand tools  
Harvesters  
Lift/ladder/pallet jack  
Light meter  
Mop and squeegee  
ORP, DO meters  
pH meter  
Phone/Apps  
Pipette  
Plumbing equipment – pumps, etc.  
Power tools (drills, saws)  
Power washer  
PPE  
Scales  
Scissors & pruners  
Seeders  
Sensor specific software  
Shopvac  
Spectrometer  
Statistical software (R, SPSS)  
Sterilization equipment (autoclave, steamers)  
Timers  
Transplanters

## **Acronyms**

EC	Electrical Conductivity	ORP	Oxidation-Reduction Potential
DO	Dissolved Oxygen	P&L	Profit and Loss
ERP	Enterprise Resource Planning	PM	Preventive Maintenance
GAP	Good Agricultural Practices	PO	Purchase Orders
GHP	Good Handling Practices	PPE	Personal Protective Equipment
GMP	Good Manufacturing Practices	PS	Product Safety
H/S	Healthy and Safety	QA	Quality Assurance
HACCP	Hazard Analysis and Critical Control Points	QC	Quality Control
HVAC	Heating, Ventilation, and Air Conditioning	RH	Relative Humidity
IPM	Integrative Pest Management	SOP	Standard Operating Procedure
ISO	International Organization for Standardization	VF	Vertical Farm
KPI	Key Performance Indicators		